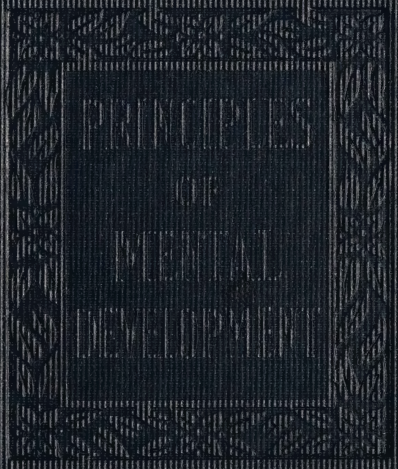
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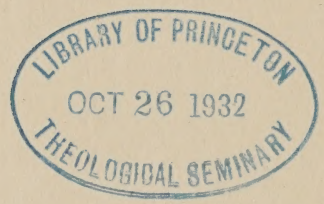

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A TEXTBOOK IN EDUCATIONAL PSYCHOLOGY

BY
RAYMOND HOLDER WHEELER
and
FRANCIS THEODORE PERKINS
University of Kansas

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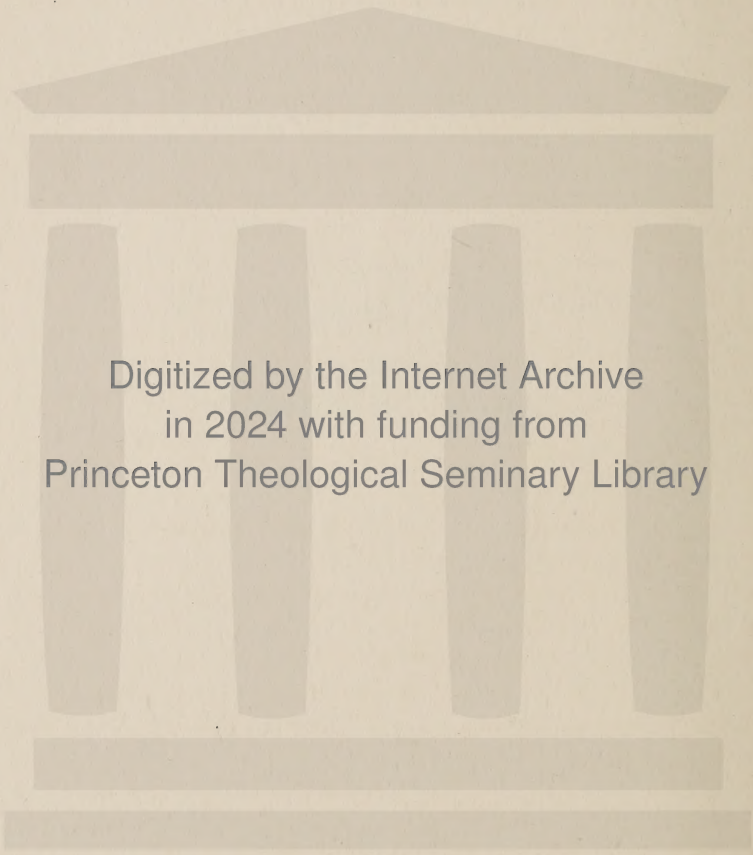
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PREFACE

Recent developments in Biology, Neurology and Psychology have been slow to find their way into the field of Education. Since these developments demand a revision in points of view regarding the nature of the learning process, the mental development of the child, and methods of instruction, a textbook in Educational Psychology, based on the new discoveries, should prove to be useful for prospective teachers. Not only the sciences just named but in all science, including Physics and Mathematics, radical changes are taking place. These changes all have the one feature in common of repudiating atomistic and mechanistic preconceptions, based upon absolutistic methods of thinking. In Physics the movement, now familiar in a general way to everyone, is based on principles of *relativity.* In Biology the corresponding development may be characterized as *organismic,* while the advances in Psychology have their origin in the concept of *Gestalt.*

Since the main feature of all these developments is logically the same, even the most conservative of thinkers are forced to the recognition that a new and general basis for an interpretation of Nature has been discovered. This fact becomes all the more obvious when one inspects the history of science. Since man first attempted to give a rational account of natural phenomena, mechanistic assumptions have prevailed. That they are now being abandoned, independently, in practically every branch of human thought, is reason for the supposition that progress in science, including the conception of problems for experimental attack, is a product of evolution. That the progress should have been made independently by specialists in various fields gives added weight to its significance.

These facts explain why experiment has yielded such striking and surprising results. Progress is not alone a matter of empirical discovery. Theory advances with experiment and experiment with theory, and at all times theory has prevailed

upon experiment as much as experiment has prevailed upon theory. The two evolve as a unit. This means that experiment does not prove theory any more than theory proves experiment, and that there are always two criteria of scientific truth, consistency between controlled observations and consistency in the assumptions and reasoning processes which give the observations meaning. Science has learned an extraordinary lesson, namely, that facts neither prove themselves nor, alone, prove a theory. A theory must be inspected in and for itself or it will dictate the facts. For nearly two hundred years the facts of Physics have been dictated by mechanistic assumptions. Psychology and Biology have undergone precisely the same history. Now it is recognized that science neglected to inspect its assumptions as carefully as it collected its data, and as a consequence misunderstood its data. It now realizes that familiarity with assumptions leads to contempt of their potency, and that, unwittingly, science has been harboring an uninspected and obsolete philosophy, reduced by social heritage to the status of common sense.

It is this situation that accounts for the reticence with which the facts of experiment have been received. Science has not been immune to indoctrination and to the influence of intellectual *mores*. Small wonder that, after a single set of assumptions has prevailed for centuries, a sudden change brings with it confusion and distrust, even a neglect of evidence. And in proportion to the revolutionary character of the evidence, one is justified in caution. At the same time, however, the greater the discrepancy between new ideas and the old, the more imperative the demand for unprejudiced inquiry.

Man is approaching a cross-roads where the new path to be chosen cannot be traversed except by the aid of Psychology. Civilization has been built up largely by an engineering of the forces of external nature. From now on there must be equally as efficient and painstaking an engineering of Human Nature, and Psychology has an unrealized problem ahead of it. Its main task is to guarantee a more adequate training of the developing mind. This training must be based upon the realization that Education is ineffective unless it teaches the individual *not only the business but the art of living.* Instruction

in the one rests upon the same scientific foundation as instruction in the other, but in the first it lacks culture; in the second it must have culture.

The following Text aims to present a Psychology for Education which relates the facts of experiment to the demand of the growing mind to live not only efficiently but with artistic and moral expression. The facts of psychology are not to be abstracted from the struggles and idealisms of Human Nature. When abstracted they are unreal and fictitious; they do not pertain to a living being, and when imposed upon him they lead only to waste and intellectual sterilization. Psychology has yet to realize that it is the Science of Human Nature, not the science of sensations, reflexes, mechanical conditioning processes and bundles of urges. It has yet, in general, to make the discovery that man is NOT a machine, that the laws of his behavior are the laws of intelligence, will and personality, not the laws of association. The facts of experiment that follow, therefore, have been given an interpretation not always specified by the experimenters. When one takes this liberty many of the old experiments have far greater value than if left with the experimenter's own conclusions. The data are good, but require reinterpretation in the light of recent advances in the science.

All this raises a practical question in pedagogy. The student is unable to grasp even the basic elements of the new Biology and Psychology *without being told why his common sense conceptions are wrong.* Unless the logic of his preconceptions is pointed out to him and contrasted with the basis of the new interpretation, he inevitably misunderstands the actual facts of experiment. Indeed, they have little or no meaning for him. For this reason he is obliged to unlearn much that he thought was true, before he can learn what, in the light of present knowledge, seems the truer picture. Until he acquires the ability to inspect his assumptions he makes no progress. To develop in him this ability is the task of instruction. The facts either from old experiments or the new have no ultimate value for him until he interprets them, and even the facts in their most elementary form require his interpretation, or he has not mastered them. Since this interpretation of necessity is relativistic, while his common sense is absolutistic, the most ele-

mentary grasp of the subject matter is not, at first, easy for him. But it is difficult only because of his preconceptions that have to be unlearned. A simple, distorted conception of the facts is worse than none, and better that he realize first, as last, that as science progresses, the truer picture is always the more difficult, and the one to which he had never given thought.

Not until the culture brought by the student to the classroom has absorbed the assumptions prevailing in the newer science of his age will the necessity for a presentation of 'controversial matter' be removed. He must understand the problems which opposed sets of assumptions raise by their own intrinsic nature or he has not begun to grasp the meaning of the facts. The facts are not something to be presented in a routine and mechanical fashion with no reasons offered why the predetermining view should not be inspected by the student. When this is done the student leaves the classroom with a blind faith in the authority of a lecturer or a textbook, and frequently, therefore, he is an innocent harborer of superficialities and inconsistences of thought. However innocent they may be, they are certainly no commendation of instruction at the college level. And there is always one predetermining view. Accordingly, the authors have attempted to meet the discrepancy between the organismic view and the students' inevitable atomism, not only with experiment and fair argument, but with *reiteration* of fact and principle, each time in a *new situation.*

The point of view has been taken in this text that the prospective teacher should realize, first of all, that teaching is not a mechanical process of telling facts. It is a contact made between a personality and a group of personalities, in which the imparting of knowledge is subordinate to the vitality of meaning which the teacher gives the facts by his attitudes, interest in the subject, breadth of grasp of the subject, and by the atmosphere of the classroom which he engenders. The student of Educational Psychology must realize that, whether he wills it or not, he will be an engineer of human nature. He should be prepared to face the larger problems of his task as the laws of human nature demonstrate them to be. When he enters the classroom without the keenest appreciation of his larger functions, which his choice of a vocation imposes upon him, he

fails in his capacity as a teacher. Educational Psychology has barely faced the greater issues of Education. An attempt has been made to recognize them in this Text. In the interest of these larger and more important problems for Education, conventional material on sensory processes and the physical conditions of mental work have been omitted. It is more important that the prospective teacher know about motivation than about the laws of color mixture, and the shape of Pacinian corpuscles.

The preparation of the book has depended upon the aid of Dr. S. Howard Bartley and Mr. William Blair who drew the figures for the Text, and upon Miss Peggy Perkins and Miss Ruth Waters who typed the manuscript. To them the authors express their appreciation. Constant contact with Drs. Beulah M. Morrison, Harry R. DeSilva, Donald M. Purdy, Marjory G. and Thomas D. Cutsforth, and Messrs. Byron Sarvis and Robert Brigden, have resulted in numerous valuable comments and suggestions. Frequent suggestions of great value were also received from Drs. Harry Helson and O. Reiser and Mr. Edwin B. Newman. The authors' attention was originally called to least action by Dr. Helson, and to maximum work by Dr. Reiser. The assistance and co-operation of, not to mention the encouragement from, Ruth D. Wheeler and Aimée R. Perkins are gratefully acknowledged.

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Where materials have been collected from such a wide variety of sources, and where ideas have been obtained from so many contributors, an adequate expression of obligation is impossible. Obviously, however, the inspiration for the present book comes chiefly from the works of the *Gestalt* psychologists and the far-reaching researches of C. M. Child and G. E. Coghill in Physiology and Neurology. It was a memorable day for Psychology when Max Wertheimer, Wolfgang Köhler and Kurt Koffka conceived the vision of a New Science. It was a momentous day for Education when Professor Koffka published

his book on *The Growth of the Mind,* and no less a benefit to educators in this country when the book was translated by Professor R. M. Ogden. Since then Professor Ogden's book on *Psychology and Education* has appeared. It is in recognition of the immediate value to Education accruing from the works of these two men that the *Principles of Mental Development* is dedicated to them. In so doing it is the hope of the authors that these pioneers in twentieth century Psychology for Education accept no responsibility for the shortcomings of the book. It is the belief of the authors that quotations are out of place in a textbook, and the book has been written in the spirit that facts and reasoning must speak for themselves with the authority of no name behind them. If these men, to whom the authors wish to express particular acknowledgment, will read between the lines, their contributions, it is hoped, will appear to them to have had adequate, even if only meager, recognition.

Raymond Holder Wheeler,
Francis Theodore Perkins.

Lawrence, Kansas,
July, 1932.

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PRINCIPLES OF MENTAL DEVELOPMENT

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CHAPTER I

THE POINT OF VIEW

The Task of the Teacher

Introduction. The student in Educational Psychology, as a prospective teacher, ascertains the laws of mental development that he may participate in the directing of mental growth. At the outset, therefore, he should bring to mind the major purposes which he aims, eventually, to fulfill. He must obtain a clear idea of his task and how well the educational system in which he must function is adapted to the fulfillment of his aim. There are, then, three main ideas to be formulated at the outset and to be reconsidered at frequent intervals in order that the student's main objectives will not be lost in the maze of that intricate detail which composes a training in psychology. First, What are the problems always faced by the teacher, as a personality, if adequate instruction is to be given at all times? Second, How adequate in the light of Educational Psychology are various methods of instruction and the machinery of the school system? Third, What are the merits of Educational Psychology, itself, as a set of principles by means of which to determine educational machinery, methods, and an understanding of the child? No one of these problems can be considered out of relation to the others, for the solution of each one is dictated by a common aim, that of preparing human beings for the art of living.

The Task of the Teacher: (1) Guardianship Over Personality. The task of the teacher is a very complicated one. He customarily supposes that his sole duty is to impart infor-

mation. But we know that the information will not be comprehended unless the child is in a position to receive it, and that of first importance in determining his amenability to training is his personality. It devolves upon the teacher, therefore, to facilitate and direct the development of personality in the pupil. Moreover, the child enters school with a personality already at a given stage of formation and whatever the teacher accomplishes is determined accordingly. If the child's traits of character are not properly balanced, sooner or later he will cease to learn altogether and intelligence will cease to develop.

Willingness to learn, interest in school work, initiative, cooperativeness and many other attitudes, expressed by the pupil, must be guaranteed before instruction can be effective. In no small measure do these attitudes, once the child enters school, depend upon a responsiveness of the child to the teacher. If the child and the teacher do not understand and enjoy each other, all else suffers. Teachers often convince themselves that they conceal their dislike for certain pupils or their lack of confidence in them; this is extremely difficult. The teacher's personality and attitude, therefore, are among the most potent influences of the classroom, more potent in the long run than the mechanical details of instruction.

The psychology of personality explains why all other aspects of mental development are subordinate to *persons*. Briefly, *the whole controls the activities of its parts*. Personality is the whole individual from the standpoint of behavior, and transcends all the more specialized activities of learning. Or better, the development of a personality is the whole learning process of the individual, and this whole is fundamental in conditioning the specialized learning processes that the curriculum is intended to promote.

(2) Stimulating the Development of Intelligence. Second, the teacher must stimulate the development of intelligence. This is achieved only with a maintenance of *rapport* with the personality of the student. Here, the teacher's conception of intelligence will go a long way toward making his efforts a success or a failure. To regard intelligence as a 'capacity' is to place a stumbling block in the way at the outset. Intelligence is made, not born; heredity plays only one part in the making.

Science repudiates the postulation of a 'capacity' defined as something of which the child possesses so much and no more. In practice such a view leads the teacher to hunt for the predetermined limit of that 'capacity,' or to imagine that he has found it when the child fails to respond. The teacher loses interest in the slow learner, assuming that there is an unremedial lack of 'capacity' within him. The influence of these ideas is subtle; it reveals itself, unrealized, in the spirit with which the child's situation is handled. The stupid pupil is recognized as a problem child and is trained by methods selected to fit his stupidity rather than methods calculated to raise him to a higher level. The method of raising him to a higher level is not alone an imposition of intellectual tasks of the proper difficulty, but a matter of motivation and, once more, a reshaping of the child's *personality.*

Causes of Retarded Intellectual Growth. A student reaches a certain level of development and stops, not necessarily because the limit of his intelligence has been reached, but because he meets a general situation that inhibits further growth. The causes for this inhibition are many. In some instances the limit set by a defective 'inheritance' may have been reached. Perhaps the difficulty is a social one in which the pupil has become maladjusted, emotionally, to the life around him. By far the most common cause, however, is a sheer intellectual sterility induced by faulty instruction.

Importance of Culture. Intelligence will grow only when the individual remains in contact with intelligence around him and with the culture of the race. He must have access to the products of superior achievement. The most ambitious of youth, since time immemorial, have demanded contact with these achievements.

The young child is already familiar with this culture, at his own level. It abounds in children's stories. It is the culture of legend and action, the achievement of undeveloped man before modes of intellectual expression and feeling diverged. Literature, almost alone, keeps the growing child in touch with culture. Arithmetic, spelling, history, geography, and other subjects, are presented to him as devitalized intellectual products, having nothing to do with a life of feeling. The intelli-

gence which education is calculated to develop will not grow when uprooted from the background of feeling from which it springs. The creative processes of mathematicians, geographers, historians, depend upon a life of feeling seldom portrayed to the child at his level of understanding. The subject will of necessity be dry, and it will be difficult in proportion to its dryness. The whole dilemma can be avoided by providing the background of feeling so evident in the customs, beliefs, cultural needs, and strivings of the race at the age of civilization when these different branches of thought were first evolving.

But *the method of presenting* this culture to the child as a ground upon which to build his knowledge is of paramount importance. It must be done with color, atmosphere, and simplicity, with the feeling and language of the age for which it is intended. *The child learns just as the scientist or artist creates, with an imagination that is vivid and a feeling that is intense.* If these fountains of learning are not to be drained at the outset, school subjects must be taught with vitality. They must be presented as something in themselves alive.

As it is, school subjects become more and more abstracted from life as the child proceeds; then he loses contact with culture until, as an adult, he finds it for himself. By this time, however, he has been removed from it so long that he has lost an appreciation of its value. Instead, he has developed a 'practical mind,' whose sterility becomes the target of jokes, and an object of pity.

Control of Intellectual Growth. The growth of intelligence can be retarded by an educative process that is too slow, or it can be retarded by a process that is too fast. The child, especially the brilliant one, always attempts to keep pace with the demands that are imposed upon him. It is easy, therefore, to hurry his development so intemperately that, sooner or later, he suffers from over-stimulation. Then the growth of intelligence suddenly ceases, with the appearance of various personality maladjustments.

Not of minor importance among these problems is precocity. On the whole, precocity is not to be desired, because the child is forced to associate with companions who are physically

older and maturer than he; whose interests are different; whose attitudes are different; whose personalities are different; in short, in whose company he is utterly a misfit. This situation, alone, is likely to react unfavorably upon the further intellectual growth of the exceptional child. Equivalent difficulties arise in connection with the retarded child.

The problems confronting the teacher with respect to the guidance of intellectual growth in children are, therefore, as complex as they are numerous. They all demand thorough study, and above all, unmistakable appreciation of the fact that the happiness, welfare, and future lives of human beings are at stake.

(3) The Problem of Motivation. A third task of the teacher is the *motivation* of the child. Under this general heading there are problems pertaining to the willingness of the child to master his lessons, his interest in school studies, his intellectual curiosity, aggressiveness and independence. But there are also problems pertaining to obedience, co-operation, and responsiveness; more specifically, problems of stealing, lying, bullying, showing hostile attitudes toward companions and toward the teacher. Here, therefore, appears the question of discipline by reasoning with the child, and by the use of rewards and punishments. And here again, a thorough understanding of psychology is essential. There is, however, no set formula of motivation which can be applied to all children; each child is a special problem, to be studied in the light of general laws in order to ascertain under just what circumstances the laws are to be applied.

Any point of view that regards rewards and punishments as special agencies acting upon the learning process will yield fatal results, because the point of view is wrong and leads to incorrect methods. To make a performance pleasurable or painful is *not* the way to facilitate it or to inhibit it. It is not pleasure, as such, that a person seeks, or pain, as such, that he avoids. Contrary to the advocator of 'soft pedagogy,' failure is as important a positive motive for learning, in the long run, as success. Too great a reliance upon unfortunate methods has often led, in discipline, to exactly the opposite results from those which were intended. This is because the relationship of the

feelings and emotions to the learning process has not been adequately understood.

(4) Directing of Specific Learning Processes: Overemphasis upon 'Efficiency.' A fourth task of the teacher is that of directing specialized learning processes in the student. He must teach arithmetic, spelling, grammar, history, and science. Too often the teacher supposes that this is only a matter of giving assignments, hearing recitations, correcting errors, and following a prescribed outline prepared for the course. *Methods,* important as they are, of producing efficiency in these specialized learning processes, should not be emphasized in the classroom *at the expense of the larger problems of which these are only the parts.* This is because the child's personality, will to learn, and sense of values, control his progress in school subjects. Little gain results, after all, from efficiency methods unless the larger whole, in which these methods must play their rôle, *is equally* safeguarded. Often the source of difficulty in learning spelling or arithmetic *is sought in the internal machinery of the process itself, which is the last place to look.* When the child's cultural interest in learning and his desire to learn are sufficiently protected, the details of mastering the school subjects will, in most instances, take care of themselves.

Dangers of Utilitarianism. While the amount of time required to learn arithmetic is being shortened, and the method of teaching history is being improved, the utilitarian philosophy: "Teach only that which is practical and immediately useful" is likely to be overdone at the child's expense. Curiosity, independence of thought, initiative, the desire to learn, are not controlled by ulterior motives of practicality and use, in the popular sense of these terms, not, at least, in the behavior of the child. *Discoveries, new ideas, accomplishments, are their own rewards.*

When the child reaches adulthood and faces the responsibilities of earning a living, then things are done, in part, for the sake of their utility. While it may be of great value to stimulate interest in science by demonstrating how a physical principle is used in a pump, or in a block and pulley on the farm, too much of an emphasis merely upon the *practical* use of a principle deadens insight into its theoretical importance, its im-

portance in leading to further thought processes, and to additional problems. The passion to play with ideas in order to ascertain where they lead is something which every normal child possesses. There is, therefore, the vital problem of teaching a subject in such a way that, regardless of its practical use, its *intellectual* and *emotional appeal* to the pupil will not be jeopardized. The value of any subject will force itself more effectively upon the growing intellect if the laws of growth are applied, rather than the attitudes of the commercial world. If the latter are to be emphasized, they should be carefully subordinated to the former in order to prevent giving the young student the notion that practical utility is the only yardstick by means of which knowledge should be measured. Once he obtains this notion, the genuineness, sincerity and spontaneity of his interest in knowledge and truth are gone.

Ulterior Motives. Ulterior motives abound in our educational system from its beginning to its end. If a child in the kindergarten comes to school dirty, the teacher seats him with the 'black pigs'; if he comes to school clean, she seats him with the 'white lambs.' Such expediencies do not teach Johnnie the virtues of cleanliness, but rather, arouse hostility between him and the teacher, and unnecessary social stratification among the pupils. Stars, honors, grade-points, forty per cent rules and all other methods of this kind, designed to increase the interests of students in their work, are not needed by those who know the value of an education, and who work because of a genuine desire to work. On the other hand such methods will teach no student the value of an education or give him an interest in his work. They drive students to drill, memorize, cheat and adopt numerous other non-genuine techniques of 'getting by,' in order not to 'flunk,' in order to be eligible for football, or in order that their fraternity will not be at the bottom of the scholarship list.

The psychology of motivation, then, strikes at the very heart of educational methods. Ulterior motives have come to dominate through a misconception of the learning process. It is in the interest of this serious problem that considerable time will be devoted, later on, to the psychology of motivation.

A Setting for Problems in Education

Learning a Process of Growth. Mental development is a process of growth that commences before birth and *continues throughout the life of the individual.* It is a learning process which for twenty years expands within an organized system of education from the kindergarten to the university. It is not the purpose of this educational system to make possible mental development under the assumption that it would not be possible otherwise. It is inevitable, under normal conditions, that children learn something, as inevitable as the fact of physical development, for learning is that aspect of growth that is observed through the individual's behavior. Learning is the realization of a growth potential, set up by a physical and social environment, just as a gain in height and weight results from a growth potential obtained from oxygen and food.

After a person reaches his maximum in height and weight he continues to undergo gradual changes that involve the whole body, including the brain. It is quite probable that this change in the brain is a continuation of the same growth that commences before birth and goes on during childhood and youth. The muscles and bones of the body usually cease to enlarge by the time a person is twenty-five years of age; but the brain undergoes additional development that is equivalent to an enlargement.

The Purpose and Adequacy of Education. It is important to realize that formal systems of education do not necessarily cause this growth process. In the normal child, mental development of some kind is inevitable, provided his environment gives him an opportunity. It is the purpose of a system of education to increase these opportunities, to supply the content for this development, and to direct it by furnishing a goal. It is the purpose of psychology to reveal the ways and means of efficiently administering this education through an application of the laws of learning.

There are pupils who do not learn readily under the prevailing system; some, because the system is too easy; some, because it is too difficult; others, because they are not receiving the motivation which their personalities demand. There are

teachers whose personalities are responsible for an unwillingness to learn; then the student may lack the inspiration to prepare himself for a successful career. Methods of presenting the subject matter, some good, some bad, affect the amount of learning accordingly. Frequently the rate of learning is either too fast or slow to fit the student's natural rate of growth in the subject. As a consequence he becomes discouraged, perhaps hostile in his attitude, a condition under which his learning suffers still more. A student may be socially maladjusted and his inability to learn caused by removable factors in his social environment. Unless these various hindrances to learning are known, the student becomes an innocent victim of neglect.

There are teachers who regard our system of education as an eminently successful one. There are others who are quite as certain that the system is a failure. Both are right, depending upon the chief aim of education. If this aim is to provide educational opportunity for the masses, it is fairly successful; if it is to supply each student with an opportunity to learn the maximum in a given time, it is unsuccessful, for methods adapted for mass education leave unsolved many problems pertaining to the individual. If the chief aim of education is to inspire the more gifted youths to work at their highest level of efficiency in order that their potentialities for inventiveness and leadership may be realized in scientific and social progress, the system is more or less of a failure. Somewhere along the line the passion to investigate and to create, so typical of every child in his earlier years, is deadened by formal, unattractive and pointless drills. Consequently, we lose nearly sixty per cent of the best young men and women who enter college, either because through mass production methods they have lost their desire for the type of development a college environment offers, or because the college does not offer a sufficiently meaningful curriculum. Proof of this fact is found in the few students so desirous of a college education that nothing short of starvation will keep them from the campus. They are the students who hunt for culture in the library and find romance in the laboratory in face of inadequate courses and unwarranted impositions upon their freedom. These are all psychological problems, from the more particular case of why John does not learn

his arithmetic to the more general one of why so few students enter college primarily to learn.

Necessity of Criticism. In training himself to become a teacher the student has selected a field of new and fresh opportunities where older conceptions are being supplanted. But to see these opportunities and therefore to become a successful teacher, the student must learn criticism through experiment; he must learn the process of inspecting hidden assumptions in his thinking. Then he must fit experiment to his reason and reason to his experiment. It becomes necessary, therefore, to compare new ideas with the old, that the limitations of the old may explain the importance of the new, and that the advantages of the new may become evident through the inadequacies of the old. Only then will his problems be adequately enough understood to guarantee their solution.

Magnitude of Opportunity in Education

Changing Conceptions of Nature. Previously, in the history of science, events and objects in nature were construed as rigid, inflexible 'things' having the same properties and behaving in the same way under any and all conditions. It is now known, however, that these events and objects have *different* properties and *different* meanings when studied in the light of *different sets* of conditions. This is a change from *absolute* to *relative* modes of thought. For example, the speed of a race horse is fast when compared with a human being, walking, and slow relative to an airplane. When, from within a moving box car, one throws a ball against the side of the car and catches it on the bounce, the distance travelled by the ball may be fifteen feet with respect to the thrower and the space frame of the car, but if the motion of the train be admitted to the picture, then the distance travelled by the ball, with respect to the earth, is greater than fifteen feet, in proportion to the speed of the train. There is nothing absolute about speed or distance.

There is nothing absolute about the attributes, qualities and performances of human beings. There is nothing absolute obtained from heredity; no fixed intelligence or particular traits of character. These, like speed and distance, are relative to

selected points of reference and sets of conditions. Both the points of reference and sets of conditions are subject to change.

But these are not the only ways in which a change from absolute to relative modes of thinking has affected scientific thought. Absolutism makes the assumption that the first things in nature are elements or indivisible parts, and that anything complex is a combination or synthesis of these elements. The physicist formerly supposed all forms of energy to have been built up from fixed elements of some sort. He began with parts and attempted to account for 'wholes' as if the latter were *composed* of their parts. Now he proceeds the other way. He begins with systems or fields of energy and accounts for the parts in terms of the properties of the system or field.

In biology, the same change in point of view is evident. A complex organism was explained formerly by a process of cell multiplication, where each cell 'learned' somehow to co-operate with its neighbors in such a way that, when the organism had developed, there was unity and harmony in a vast aggregate of cellular units. The cells formed the body. Now it is known that the situation is exactly the reverse; *the body forms or grows its cells under a set of laws which pertain to the whole organism as an individual unit.* Cells do not explain the body; the body explains the cells!

Introduction to the Change in Psychology. The same reversal of fundamental conceptions has taken place in psychology, which means that the behavior of human beings presents an entirely different picture than was formerly supposed. It means that the best methods of guiding mental development are not those popularly in use. Investigations of the twentieth century bring out that the mental life of the individual and all his modes of behavior follow the same laws already implied in the case of physics and biology. The whole controls its parts; the 'mind' *develops* its experiences; experiences do not form the 'mind'; a growing, single *pattern* of behavior 'divides' into all manner of skilled activities. Activities are not learned separately and *put together;* they are self-expressions, at all times, of an individual, organic unit, whose main object is to preserve its unity. Thus, the student will discover, as he proceeds, that the modern conceptions of mental life and of how human beings

learn *are in sharp contrast to the common-sense ideas which he brings with him to class.* These common-sense ideas are based upon the same modes of thinking which, in the case of the physicist, the biologist, and the psychologist, caused them at one time to construct an erroneous picture of Nature, including man.

Reasons for the Opportunity. Psychology, like the other sciences, has changed with advancing knowledge. It formally gave educators *a wrong conception of the individual and of what they were trying to make him do in school.* Pupils have been trying to learn by methods which do not harmonize with the laws of learning. It was not known how learning actually took place. It has become evident, therefore, that methods must be changed in accordance with newly discovered laws of mental development.

The teacher must know his psychology as well as the engineer his mathematics and mechanics, the physician his chemistry and anatomy, the lawyer the profound intricacies of the law. The efficiency and normality of the human mind depends as much upon the persons who direct its growth, as the building depends upon the engineer, and the life of a patient upon the physician. Normal intelligence, emotional attitude and personality are *formed* by the humanity surrounding the individual. The prospective teacher is learning how to mold human lives. The educative process is not primarily a matter of teaching that two and two are four, or that the Mississippi River has formed a delta, or that Washington wintered at Valley Forge. These are secondary. Facts do not of their own accord teach human beings how to live. Human beings must know the significance of these facts.

The Problem Restated. The teacher is a human engineer, building intelligence and personality in his pupils. Superficial knowledge in mechanical engineering would mean a defective building or a defective bridge whose collapse might cause the snuffing out of human lives. Superficial medical knowledge might result in the unnecessary death of unnumbered trusting patients. No one knows to what extent superficial psychological knowledge, applied in the course of managing human nature, results in lost opportunities, sterilized ambitions, discouraged

efforts, delinquency, crime, special mental deficiencies, and disintegrated personalities. Does the contact of human nature with human nature, especially in the classroom, enliven the preexisting interest, increase the ambition, unfold the hidden potentials, raise the intelligence, enrich the life? Or does it lessen the interest, deaden the ambition, lower the intelligence from what it should have been at any given stage in its development, and send the individual on handicapped in opportunity for achievement and happiness for the remainder of his life? The child is as dependent, for his growth, upon the human nature around him, as the building upon the engineer, and the threatened life upon the physician. Growth is spontaneous only in the presence of opportunity; there is incentive only where there is something in which to be interested; there is potential only where surroundings provide the conditions for potential. The child is equally helpless, independent, and aggressive.

Spontaneity and Dependence in Mental Development. The problem of education becomes a problem of directing growth, and the technical name for that growth is *maturation.* The child is born with practically no intelligence, with the lines of growth by now partly fixed and partly flexible. While this growth comes from within, necessary energy comes from without, whether the growth be physical or mental. Thus, in the child, there is a curious balance of spontaneity and dependence, a balance that is difficult to adjust. An individual is developing who must at the same time be independent and dependent; his spontaneity, natural interests, and creativeness, which are the very fiber of his being, must be preserved in an environment that will exert limitations upon him. Strange as it sounds, this spontaneity depends upon the right kind of restriction from without. The child's demand for freedom of self-expression depends upon restraint, correctly provided. The humanity in the child that brings him in conflict with the humanity around him, depends for its life upon that humanity. But the apparent incongruity of these facts melts away before a basic law of nature that holds in the human and physical world, alike, the law of action and reaction. In human life it is a give and take. The science of psychology strives to direct this 'give and take' process between the child and its human environment *to the end*

that it is an orderly process when the child becomes an adult. The fundamental purpose of Educational Psychology is to apply the laws whereby maximum freedom of the matured individual can be guaranteed, together with a maximum freedom of that human mass we call society.

Summary. The prospective teacher should realize, first of all, that the mere giving of information will be a small part of his task. He is helping mold the child that the child may know how to live as an adult. Living requires more than 'practical' knowledge; the feelings and personality are involved, and they are basic to knowledge. In order, therefore, to present knowledge in such a way that it will be effective, the teacher must *know the psychology of human nature,* especially of the feelings and personality.

Second, the prospective teacher should realize that the science of Educational Psychology is in its infancy. It is merely beginning to uncover the intricacies of mental life as they appear in the classroom. At a time when the science is passing into a new era in its history, together with other sciences, new concepts and modes of expression stand out in considerable contrast with the old. Old conceptions of learning, intelligence, heredity, indeed, of the very fiber of human nature, are taking on a fresh and startling interpretation. And with these changes are coming a new vision of the teacher's task and new methods of instruction.

Third, the point of view of this text, as far as the teacher is concerned, emphasizes his importance as a personality in the teaching process. With respect to the facts and theories of behavior pertinent to the process of teaching, those will be emphasized which give the broadest and most comprehensive view of the child developing under physical, biological, and social conditions. This view recognizes the relative character of human responses and seeks to establish the laws that furnish a coherent account of the human being as a whole.

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CHAPTER II

THE LAWS OF HUMAN NATURE

The New Point of View

Introduction. Since man is a part of nature his behavior follows laws that apply to nature generally. Since he is a *system of energy* his behavior follows laws of energy. These facts have been demonstrated in the biological laboratory, first, by experiments on motility and growth of nerve supply in animal embryos; and second, by experiments on the functioning of the developed nervous system throughout the animal scale. Moreover, the behavior of these animals from the goldfish to the ape, the behavior of children, and of adult human beings, demonstrates the same laws over a wide range of phenomena. These are not mechanistic laws, requiring the assumption that man is a machine. In fact the laws prohibit a machine interpretation, not only of man but of any object in nature, and make unnecessary any ultimate, scientific distinction between the mental and the physical.

Fallacy of the Mechanistic Point of View. Unknown to him, the common sense with which the student regards nature *is mechanistic,* and since the laws of behavior are *not* mechanistic there are various assumptions that, at the outset, he must unlearn. This means that he faces a problem in logical thinking. What is this problem? The mechanistic conception of nature is based upon the false assumption that the complex is to be explained in terms of the simple. This means that wholes are to be explained in terms of parts, which in turn implies that parts come first. For example, a chemical compound is to be explained in terms of elements; the body by means of cells; consciousness by means of mental elements known as sense 'impressions,' ideas and feelings; movements by means of elements known as reflexes.

When the assumption is made that parts come first a difficulty is encountered at the outset. The parts have not yet been put together; each is an isolated 'individual.' Then, if each part is in the beginning out of relation to any other part, by what means can they be put together, or made to influence one another? *There is no way,* for the only way one object can act upon another is through the medium of *a pre-existing relationship between them.*

What is relationship? It is a mutual dependence, described as a dynamic relation, that means a change in one part whenever there is a change in another. If there is granted such a dependence between the parts in the beginning, there is more, in the beginning, than the parts. There are the relationships between them. In reality, therefore, an element or independently existing part is a fiction.

Examples. Can you think of half an apple without implying the previous existence of the *whole?* The object, in reality, was a whole from the instant it began to grow, and, at any stage in its development it may be divided into two halves only by beginning with the whole. The whole comes first and explains the parts.

FIG. 1. THE 'SQUARENESS' OF THIS FIGURE IS AN EXAMPLE OF A FIELD PROPERTY.

Observe a square. (Fig. 1.) Technically the observation is called a *perception.* Is the perception of the square made up of the four lines and so much space *put* together? By no means. One may have the same lines and space arranged differently, in the form of a triangle, with a fourth line added to it. It is now a different figure, but 'composed' of the same 'elements.' The 'elements,' then, do not account for the figure. Similarly there are many chemical compounds, all involving the same elements, carbon, hydrogen and oxygen, but *in different proportions.* The proportions, not the elements, make the compounds differ from one another in their properties. Proportion is a property of the total molecule, not a property of its ingredients.

Look at Fig. 2. The corner dots become the ends of an 'X' or the corners of a square; the central dots in the outside

rows can become either the ends of a plus-sign or the corners of a square. The elements of the figure are the same in any case, but the figures are different. These illustrations show how the complex cannot be explained in terms of the simple. *Parts do not come first.*

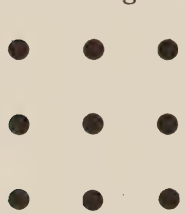

Fig. 2. Dot Figure, Illustrating Various Possible Patterns or Groupings.

The 'X' pattern and 'plus-sign' pattern are further examples of field properties. Note that it is the field property that describes the unique characteristic of the figure as a whole.

Organismic Laws

The Law of Field Properties. The fact that wholes are primary introduces the first of several principles which may be called organismic laws because they imply the organic or unified character of objects in nature. This law is the *law of field properties* which states that *a whole is more than the sum of its parts.* It is evident that an apple, cut in two, is not a whole apple, although both parts still exist. Take a man's head, trunk, legs, stomach, brain, all his parts; scatter them over the top of a table, and there is no man. Parts must be in certain dynamic adjustment to each other or the whole does not exist. Listen to a melody like "Annie Laurie." If the notes were played backwards, or in haphazard order, there would be no melody, nevertheless, all the parts would be heard in combination quite as much as in the familiar melody.

In each of these illustrations the whole is something distinct, unique, over and above the parts, *yet it includes the parts.* It is a unit reducible to parts but the parts have no meaning unless referred to the whole. Returning to the square, squareness is a property of the figure-as-a-whole. The familiar melody, "Annie Laurie," is the musical property of a succession of notes taken as a single unit; the life exhibited by a human being is not the property of his separate parts but a property of the unified whole. Properties like squareness, melody, and life, are properties that pertain to complex units. A square is an *area;* a melody is a *temporally extended range* of notes; the living organism is a *mass* of tissue. Hence, properties pertaining to these complex wholes are called *field properties.*

Tangibility of Field Properties. There is nothing mystical about a field property. It is observable as squareness, as melody, and, in case of the human being, as life. Field properties *are measurable.* The square has definite dimensions. A melody has degrees of definiteness and satisfyingness. The life of an organism can be measured in terms of activity. There are many other examples. Around the earth is a layer of air that, in the upper strata, is highly rarefied. In the lower strata, next to the earth, it is more dense. Objects on the surface of the earth are relatively more dense than air, but far less dense than the material at the center of the earth. There is a density gradient or range, then, extending from the outer margins of this gravitational system to the center. This gradient is a field property that can be measured. A study of the nervous system will raise the problem of physiological gradients, or field properties of the total organism. These gradients, also, are measurable, and cannot be ascribed to separate parts of the organism.

Human Nature a Field Property. Human nature is a field property of *societies.* If a thousand hypothetical individuals could by some miraculous means survive and mature, each isolated from the other and from all life, none would develop a human personality. None would acquire ideas of right or wrong, emotions of fear, love, or anger; none would exhibit intelligence, or develop a consciousness. These persons would be hypothetical statues of flesh and blood. They would have no customs; there would be no public opinion, no laws, and no religion. In short, it is only by living together in societies that individual human beings acquire their human nature. This means that human nature pertains to the social whole that is more than the sum of its parts. The parts are the individuals, which, like the parts of an apple, or the notes of a melody, imply a whole upon which they depend.

The Law of Derived Properties. *The law of derived properties* states that *parts derive their properties from wholes.* Return to the square. The squareness of the figure-as-a-whole gives to the lines the property of equality. Why are the angles all equal? Why, if diagonals are drawn, will they cross each other exactly in the center of the square making four right

angles? If the figure were a rectangle, or a diamond, none of this would be true. The character of the figure as a whole gives to the parts their individual characteristics.

Think of a stone. It has weight. Imagine the stone existing in the absence of a gravitational field. Then the stone would have no weight, for weight is a relation existing between the stone and the gravitational system. Thus, weight is a *derived property.* Similarly, a particular note in the melody, "Annie Laurie," has a certain pitch, rather than any other, because of its position in the melody. Shift a note to another place in the melody and it would not fit. Again, think of the series of numbers 1 to 9. Each number derives its mathematical value from its position in the series. If the number which occupies third place were in the seventh place it would have to be seven instead of three. Consider a step in a stairway. If the same boards were lying on a lumber pile they would not constitute a step. Their position in the stairway gives them their step-property.

Personality a Derived Property. Human beings are no exception to this rule. They are parts of a human organization called society; they derive their personalities from the human nature-pattern around them in the course of growing to adult membership in this society. Personality is the membership-character of a human part in a human whole. The social group is as necessary for personality as a square is necessary for the side of a square, or as a gravitational system is necessary for the weight of a stone. It can be seen at once that the control of personality must be found in the character of the human nature that surrounds the individual. Again, by way of analogy, a tiny object forms in the disappearing flower on an apple tree. Because it is a tiny object, hanging in a gravitational system, it has weight; it grows; it expands. But it absorbs energy from its surroundings. All this energy has weight because it, too, belongs to the system. The apple acquired its weight from its surroundings.

Similarly, the infant is an undeveloped personality. His energy, to be sure, comes from food and air, but it is aligned by the character of the stimulation received from the behavior of others. He absorbs the characteristics of those around him

in the sense that the human influences of his environment take form in the energy that is accumulating in his nervous system. Thus an individual can no more derive personality without a field of personality to draw from, than an apple can gain in weight without available energy in its environment.

The Law of Determined Action. The law of derived properties is closely related to the next principle, namely, *the law of determined action,* which states that *the whole determines the activities of its parts.* The idea of a square-as-a-whole determines how one shall draw the lines. The musician's original feeling for a certain melody as a musical unit determines his selection of the individual notes.

A total gravitational system conditions the behavior of objects within the gravitational field. It determines the direction in which bodies fall. It gives to objects, situated in different places in the system, potential energy which, upon being released, will change to motion, or kinetic energy. A steel ball, one inch from a glass plate, will fall upon the plate with a moderate thud, with no damage done. Change the position of the ball with respect to the system by raising it to a high altitude above the plate. Here the ball is under higher gravitational potential, that is, it has greater possibilities of motion. Dropped, it will gather momentum, or kinetic energy, sufficient to smash the glass when it strikes. The difference in the two cases is conditioned by the changed relation—the increased distance—between the ball and the gravitational system as a whole.

Generality of the Law of Determined Action. Objects move as far as the whole, of which they are parts, will let them. When a person draws a radius of a circle he cannot go beyond the circumference and still be drawing a radius. When he draws the side of a square, squareness determines at what point he will turn at the corners. If he places a cold flatiron against a warm one, heat will flow until the temperature field, composed of the two objects, is homogeneous, or in other words, until both irons are of equal temperature. The unbalanced character of the temperature field, one iron hot and the other cold, determined the flow from one to the other; then, the balanced character of the field determined the stopping of the flow.

Let a tunnel be bored, hypothetically, through the earth.

Drop a stone down the tunnel. It would gather momentum as long as it was approaching the center of the earth. It would pass on, but begin at once to lose momentum; eventually stop; retrace its path by the center; reverse again, like a pendulum, until it came to a halt at the center. Again the character of the field as a whole determined how far and how long the stone would travel; determined its reversals and finally the place where it came to rest.

The Individual and the Group. Society determines the activities of its members. Social groups develop different customs, moral codes and laws, and these are imposed upon the individual. If one is Chinese, subjected to a Chinese environment, one will acquire the religion of the Chinese, their mode of dress, their art, their entire culture. Born in a devout Jewish family, one's religious ideas will be Jewish; born in a Presbyterian family they will be Presbyterian. A person is compelled by social custom to eat with knives and forks, live in houses, ride in automobiles, sleep in beds, spend money, eat certain foods, subscribe to certain marriage and funeral ceremonies, address strangers in certain ways. Whereas he is free so long as he does not disturb peace and harmony in the social group, or trample upon the freedom of others, in every thought and deed he can eventually go as far as society will let him.

The Law of Individuation. *The law of individuation* states that *parts of wholes come into existence through an emergence process called individuation,* or structurization, or differentiation. You are about to draw a square. First of all there must be space. It is a field of space, or expanse, occupied by a sheet of paper. You are to take a certain amount of this space and bound it by a contour. If you were a geometrician you would consider the lines merely as crude conveniences representing imaginary boundaries. You imagine a block of space *figured* into a certain shape having symmetry of form. Through your imagination, helped by the actual drawing of lines, you have caused to emerge from undifferentiated space a pattern, a geometrical 'individual.' You have taken a certain amount of space and *structured* it; you have made a certain part of it take on *form.* A figure has emerged from a field or ground of space.

The composer of "Annie Laurie" possessed a concept of melody that corresponds to the field of space in case of the square. He did not select a note and arbitrarily locate it on the staff, then another note, and then another. A melody *dawned on him as a unit.* It may have been imperfect at first, but from the beginning it was an individual, musical idea. It emerged from an undifferentiated feeling for music and took form upon this background. It was *an invention process,* just as the drawing of a square is an invention process. A geometrical pattern is created in the one case, a musical pattern in the other. *Emergence phenomena are inventions,* the coming into being of things new.

The Law of Individuation Applied to Human Beings. Human beings are not exempt from this law. The individuality of a given person emerges as one totality from the human nature-pattern around it; it is figured, so to speak, upon a ground of human nature. The emergence of personality in the individual, like the appearance of the square or the melody, is an invention process. This time, however, the invention process is called growth.

Interdependence of Parts. All the parts of a whole are interrelated in a systematic fashion as they come into being. Every part of the square depends upon every other part. If one side is drawn at an angle of forty-five degrees relative to a horizontal base line somewhere below the figure, all the other lines must also be drawn at a forty-five-degree angle from the same base line. If the first side is three inches in length, the others must be three inches. The length of the diagonals depends upon the length of the sides. Every part of the figure, therefore, *is relative to* every other part.

It is the same with the notes of a melody. None of them has independent existence. For example, in "Annie Laurie," the first eight notes are:

Max	Welton's	Braes	are bonny
MI RE	DO DO	DO (octave)	TI TI LA

The particular musical effect given by the first three notes depends upon their successive relations to each other as they de-

scend the scale. Then the effect of the fourth note depends upon the jump of an octave. The effect of the last three notes hinges upon the fact that the second *ti* follows immediately after the first, on the same pitch, giving a distinctive character to the musical value of the *la.* It is the same in all melody. Every note depends upon every other, or in other words, upon its position relative to a series of notes. In harmony the law also holds, for there the musical value of a note depends upon the position of others that appear simultaneously with it.

Relativity and the Law of Individuation. There are numerous simple illustrations of this dependence or relativity. If there were no left there would be no right; if there were no up there would be no down. The one derives its meaning from the other. The same situation holds in the physical world. A high energy potential exists only with reference to a low. Both must exist at the same time or neither will exist, for the condition that makes one potential high is the fact that the other is low, and *vice versa.* Together they are a unit, an indivisible field. This is precisely what is meant by unity. Thus unity and relativity describe the same situation. For example, when a high electrical charge is created in one place, other charges in a surrounding electrical field become low in proportion. Heat one flatiron and another becomes cold with reference to it. In a similar fashion the personality of one individual is relative to the personality of another. A dominating personality produces weak ones around it because the latter have been forced into dependence. The conclusion is obvious that parts cannot exist alone, which means that they are subordinate to wholes.

The Law of Field Genesis. Next in order is *the law of field genesis,* namely, that *wholes evolve as wholes.* We have already said that the apple, springing from a tiny germ in the flower, was an individual from the beginning. Likewise a melody is a unit from its conception, however undeveloped it may be at first. The square was never something else before it was a square. The human being is a biological individual from the instant of his origin. He is a psychological individual from the instant he begins to have experiences.

This law asserts that wholes are not composed of parts, or

explained by parts, but, for purposes of description, are reducible to them. Parts are not put together; they *evolve together in accordance with a plan.* It was necessary to construct mentally the *plan* of a square before the four lines could be drawn in their proper relations. The musician does not draw at random from a mental basket of 'mixed up' notes to find them sounding out a melody! *The personality is not a bundle of character traits like aggressiveness, modesty, ambition, cooperativeness, good humor and intelligence,* each arising from a separate source of influence, and taking its own independent course of development. The personality evolves, a single pattern of behavior, with each act depending upon every other *while it is emerging.*

Societies have not evolved by an accumulation of individuals. To be sure, populations have increased but the increase does not furnish the law of social evolution. The social group is a fundamental phenomenon in the evolution of mankind. The history of man is a history of tribes, nations, races, cultural groups, to which individuals have always been subordinate.

Growth as Expansion. Wholes evolve through an expansion and differentiation process. As the square is drawn it expands with the emergence of detail. The melody expands and differentiates as a whole when the musician, beginning with a vague idea of the tune, polishes it by adding a note here and omitting one there. The human being grows in the course of cellular multiplication, but growth is the expansion of a dynamic field, not an accumulation of cells. As the body develops, its tissues become more specialized, or differentiated into types and organs. Societies come into being through expansion. The mere addition of numbers does not adequately describe the process. *Addition or accumulation must be defined as expansion and differentiation.*

The World of Action. The world in which we live is not static. It is dynamic, always in flux. Streams are flowing; bodies are falling; life is springing up and decaying; evolutionary processes are going on; there are electrical currents; air currents; temperature changes; wave phenomena; living organisms in action; always some kind of activity. In order to cope

with the problem of action, defined as motion, or change, it is necessary to find some basic principle in accordance with which action takes place. Whenever a given phenomenon of motion is investigated it becomes evident that there is a certain condition under which it *begins,* a certain condition under which it *ends,* and a certain condition under which it acquires its *direction.* If these conditions are not known the motion cannot be explained.

Consider a local air current. Air in a certain region becomes heated, and rises. This creates an area of low atmospheric pressure and makes the surrounding areas relatively higher. Air rushes in from the sides in the course of equalizing the pressure. Electrical currents are formed when a high charge is released in the direction of some part of an electrical field where the charge is lower. A body is poised above the earth. The body, unsupported, falls toward a point in the system where its dynamic or stress relation to the system as a whole will be equal in every direction. This point is the center. But the earth stops the falling body, exerting its pressure against that of the body which comes to rest upon its surface.

The Directional Character of Movement: Law of Least Action. Inspect the behavior of a stream, its source high in the mountains. It never runs up hill except in overcoming stress from some pressure behind. It emerges from the ground, under pressure; then it begins to flow. *Why does it proceed in one direction rather than another?* There are different degrees of slope in the land about the spring. The stream flows down the *steepest part of the slope.* When it comes to a precipice it tumbles *straight down,* again the steepest possible path. Suppose it meets with an obstruction. It backs up, overflows the barrier and circles around the protruding rise of land, again down the *steepest route available.* All this goes on until it finally reaches a water level. Although the stream has wandered, its speed now slow and now fast, each step of the way it has taken the shortest route in time toward the water level. There is a law which covers this type of behavior. It is called the *law of least action,* when action is defined as energy multiplied by time. This means that units of energy multiplied by units of time are, for a given set of conditions, a minimum.

When the stream takes the steepest possible slant, under the circumstances, it is following *the line of least action.* We are interested in the law of least action because it explains the *direction* of movement.

When it is understood what gives *direction* to a moving object, it will be clear how movements of living organisms acquire their direction. There is a field of energy of some kind in which a disturbance has brought about a lack of balance. In the illustration just given this disturbance occurred within the earth. Water was forced to the surface where nothing balanced its gravitational stress toward the earth's center. There is a vast *differential of potential* between the water in its high position in the mountains and a water level at the ocean. It is very important to remember what *differential* means, for this differential gives direction to a moving object. The direction of the movement is determined by the position of a low potential with respect to a high, that is, by the direction of the differential. In every field of energy there are alignments or gradients of potential, so that movement goes from the position of the highest potential to the position of the lowest, *down the gradient.* This is what the stream is doing when it 'picks' the steepest downward slant that it can 'find'; a differential is being resolved in the line of least action.

There is still another important point to remember. Going down the gradient is taking the shortest route in time. One must always think of movement in connection with time. For example, a stream may be confronted by a cross-range beyond which there is a low valley. It is half a mile through the range to the valley beyond and fifty miles around the end of the range. The longer route is the shortest in time. Figuratively speaking, the stream cannot spend the time and energy to wear a gorge through the mountain when the quicker way to lower levels is to go around.

The Establishing of Remote Ends. Return to the convenient apple on the tree. The stem balances the apple against gravitational stress, already supplied to the apple because of its position in the system. The stem breaks. The balance is disturbed. Instantly the apple begins to fall in a direction prescribed by an alignment or organization of stresses. But the

most striking feature of this performance remains to be described. The point of low stress at the center of the earth exists simultaneously with the point of high stress where the apple hangs. Indeed, there is an entire gravitational system surrounding the apple, *before the apple moves.* The system provides *a remote end* toward which the apple will move. If the conditions for least action hold generally, in nature, no object moves before it has some place to go. *The remote end of the movement is established before movement commences.* This is how the whole conditions the activities of its parts; it furnishes, through its organization of forces, the *beginning,* the *direction,* and the *end* of activities that take place within it.

To restate the law of least action, *the beginning of movement is a position in a system of energy where there is a high potential, but this high potential exists only with reference to a low. The movement from the high to the low takes place over the shortest route in time and is a process of equalizing the potentials.* The potentials form a whole because they are mutually dependent. The law of least action can be called a field law, therefore, because it deals with a system of energy as an 'organic' unit.

Dependence of Movement upon Factors in the Future. Imagine that you are an object falling in a gravitational system. Remember that *ahead* of you is a remote end toward which you are falling; that this goal existed in the system before you started to fall. You cannot see ahead. You are approaching a remote end that already exists in the system, but which lies ahead of you both in space and in time. This remote end is the center of the earth. The goal is in *your future,* but it is existing now in the gravitational system. When you are the point of reference you are responding to your future. A factor, ahead of you in time, is functioning in the control of your behavior. This fact may be expressed in terms of the general principle that *when a part is the point of reference, the conditions in the whole that determine the activity of the part surround the part in time as well as in space.*

Applications of Least Action. The basic law of action may now be applied to the examples already presented in connection with the other organismic laws. How does a person

draw a square? He possesses a nervous system that undergoes somewhere *a rise in potential,* which means *a relative lowering in potential elsewhere in the system as a whole.* The rise in potential is represented in consciousness by an idea of the square and a desire to draw it. The potential, thus set up, resolves itself toward a remote end. The end is the completed square. The motions made by the performer are the expressions of energy 'seeking' equilibrium over a devious route. The route is the series of motions required to complete the square. The process of drawing ceases when the task is completed, the remote end reached, for the remote end means, physiologically, resolution of the nerve potentials, and, psychologically, a gratification of the desire. The nervous system as a whole, through its streams of nerve discharges, directed the necessary contractions of muscles just as a gravitational system of mountains, valleys, gorges and plains conditioned the wandering path of the river.

The square raises the problem of least action in other ways. If the figure were exposed to an observer for one tenth of a second, it would be perceived as a square. Let the same figure be drawn, however, with the ends of the lines failing to meet by a sixteenth of an inch. Expose it and the observer will still see a perfect square; he has *completed* the figure. In terms of least action it is a simpler, quicker process, under the conditions, to see the square as if it were complete, than to see the corners broken. In like manner, proof-readers will overlook errors in the spelling of words because the quicker, easier process is to see a word as a whole spelled correctly than to see the error.

A melody must end on a certain note related in a definite way to octaves from which the notes of the melody are selected. To end on any other note leaves the melody unfinished. As a consequence a strain remains in the listener. The note that produces a satisfactory resolution of this strain is called a tonic, a key note in the scale, which is very frequently *do.* Thus "Annie Laurie" ends on *do.* Imagine it ending on *ti* or *re!* Ending the melody on *do* is like a stream reaching its water level. A musical balance has been effected, just as in the case of the stream a gravitational balance has been reached.

The Human Being and Least Action. When speaking of human beings, in connection with the law of least action, we shall think of them as systems of energy. We shall think of potentials and stresses as tensions. These tensions exist throughout the nerves and muscles, but more particularly in the brain. Man's behavior at all times is a matter of resolving these tensions. Expressed in everyday language it is a matter of fulfilling purposes and gratifying desires. The tensions are induced in his nervous system in complex patterns determined partly by the nature of events and objects in his environment and partly by the characteristics of stress-patterns that were already existing in the nervous system. These patterns of stress, or tension, are represented in the individual's consciousness by purposes, desires, wants and ideas that are constantly demanding fulfillment. At the same time, they are represented in the nervous system by physiological stresses. There are then differentials to be resolved. Whenever this condition exists, as we have seen, there will be 'action' from the high in the direction of the low *until the differential is resolved.* Thus, from a physiological standpoint, behavior is the regaining of equilibrium in a system of nerves and muscles.

But more than this, the organism's tensions are set up by environmental events and by objects with which it comes in contact. In the environment lie the remote ends which must be reached before tensions will be resolved. These ends are goals, but they are not only environmental goals, they are goals *perceived.* The organism's behavior is purposeful. Thus there are two factors to keep in mind: one, the differentials of stress within the organism and, the other, something in the environment that the organism wants. It is this relationship between the organism and its environment that is represented by differentials in the nervous system. Accordingly, the same movements that bring internal equilibrium are those which carry the organism to its environmental goal; they are also the same movements that relieve consciousness of wants and desires.

Social Behavior and Least Action. Social groups behave in accordance with the law of least action. Whenever an individual disobeys group standards of thinking and living, he stimulates tension in the group. This tension may take vari-

ous forms according to circumstances. Perhaps the group fears the non-conformer, shows hostility or disgust. Then it resolves its tension by taking action toward the disturber. If the tension is of a political character, the disturber is jailed; if he is a murderer he is executed. Resolution of tension in the group may take the form of worship and propitiation. Groups enact immigration laws in the course of resolving group tensions toward outside races, whose inroads upon their population bring economic stress. Wars are methods of resolving racial animosity, fear, and desire for power or expansion.

The Law of Maximum Work. There is another law, a corollary of the preceding, which is called the *law of maximum work.* This law states, *first,* that *any influence affecting a system of energy, affects it throughout.* This is because the entire system is an indivisible unit in which every part is dependent upon every other. No one part, therefore, *could be* affected without affecting the whole. Strike your fist against a table. The table is jarred from end to end. Open the door of a room. The air pressure in all parts of the room is instantly disturbed as can be observed when a door rattles on the opposite side. Let one side of our familiar square be drawn with a curved line. Not only is the line crooked but the square-as-a-whole is imperfect. A misstruck note spoils the effect of an entire melody. In the human being an exaggerated trait unbalances the total personality.

The law of maximum work states, *second,* that *in an energy system a maximum amount of energy, for any given set of conditions, will be expended in the course of maintaining balance.* This can be seen from the law of determined action. When the stem of the apple breaks, not one part, but all, of the gravitational system is disequilibrated; and the entire system conditions the return to equilibrium. In order words, when a force is impinging upon a system of energy the whole system offers 'resistance.' Think of the tremendous amount of energy that would be expended in removing a quarter section of the earth and hurling it off into space. The amount of work necessary to accomplish this feat measures the resistance offered by the gravitational system against being disturbed. Systems of

energy work to retain their *status quo* against forces that alter the pre-existing balance of potentials.

Human Behavior and the Law of Maximum Work. In human life this resistance is called expenditure of effort. When a person fights to prevent his destruction, he is merely obeying the law of maximum work; he is expending effort in the preservation of unity. If need be a human being, or an animal, whose life is being threatened, will fight until all of its available potential energy is expended and it faints, or dies, from exhaustion. Man will also fight for the integrity of his personality. He proves it when, insulted, he flares up in anger. He proves it when he resents new ideas that compel a change in his thinking. Change means an alteration of deep-rooted traditions and a temporary lack of harmony among ideas. Thus, when anaesthetics were first discovered, the medical profession was slow to accept them. One prominent physician declared that the use of chloroform during childbirth was not only harmful but wicked; it deprived the mother of her natural pains which were there for good purpose. To relieve her of pain was to interfere with the laws of God and Nature. These are illustrations of wholes in which an amount of energy, maximum under the existing conditions, is expended in the course of maintaining organization.

Other Examples of Maximum Work. Stand upon a pair of scales and the pointer will move along the dial to a certain value and stop. This value is never exceeded, hence the response of the scales is maximum for the existing conditions. Let salt be poured into a given volume of water. Just so much salt will dissolve and no more. Again, a student is studying for an examination. He is laboring under a certain amount of stimulation and motivation. He desires a good grade, but, against that, is a distaste for the subject. He strains himself to the utmost in order to concentrate, but to no avail. A maximum amount of energy under the existing conditions is being expended, for only a certain amount is available under limited motivation. A friend explains to him a previously unrealized value of the subject. Now the learner is interested. He can now expend more energy, for interest means a raised potential and greater availability of energy for work. Accordingly, he

throws himself into the task with sufficient vigor to overcome the distractions that heretofore he was unable to surmount.

We may return to our square and melody in order to illustrate the law further. The square with one crooked side is a total figure. The nerve energy involved in perceiving it is the energy of a total nerve field. Now expose the figure for one tenth of a second. The energy of the total field is involved in seeing the figure as a perfect square. If only a part of this energy field were involved, alone, in perceiving the crooked side, that part, alone, would not suffice in producing the illusion of a perfect square, for by definition, merely the side would be perceived out of relation to the square. In case of the melody, hearing a misstruck note on pitch involves the same principle. The note has no power to correct itself; it is because the melody is perceived as a whole that the misstruck note is detected, and this means that, in the brain, an energy system as a whole is involved in detecting and correcting the error.

The Law of Configuration. The last law to be considered, here, is the *law of configuration. A system of energy always functions as a unit, and always adjusts itself to a multitude of disturbing influences.* This multitude of disturbing influences is called a *total situation,* and the unit that adjusts itself is called a *configuration.* The laws of least action and maximum work explain why a configuration must behave as a single unit. It is a whole whose parts are dependent upon organization for the manner in which they will function. Because this is true, the effect that any single outside influence will have depends upon the effects of all the other influences.

Recall the square with a crooked side. The square is a geometrical configuration. As a square it was spoiled by the crooked side. A host of misplaced points made it crooked, and the bad effect of each depended upon the effects of its neighbors. Think of a human being observing a piano keyboard. He cannot see a key to the right without also seeing other keys to the left, for there is no right without a left. He responds to the keyboard as a total situation, and perceives one detail of that situation in relation to the others. The digestive system is a physiological configuration. It suffers a defect, not as the consequence of a single factor, but because of the relationships

which a single disturbing influence sustains to all the factors that guarantee normal digestion. This is why a nervous strain in one person will produce dyspepsia when it will not in another.

When we think of the human being as a system of energy, responding to his environment, the law of configuration means that *he always responds to one stimulus in its relation to others.* Thus it becomes necessary to regard the total situation as a *stimulus-pattern.* In the illustration of the piano keyboard, the keyboard was the stimulus-pattern, and since the observer responded as a whole to the stimulus-pattern, his response was *configurational.* His perception of the keyboard was a *perceptual configuration.*

The law of configuration implies that a system of energy is a part of some larger *whole.* A given event is the effect of a multitude of causes and these causes are in the whole of which the event is a part. It can be seen, once more, why parts never act upon parts. One part affects another only through its membership-character in the whole, that is, through its membership-character in a system of related causes. When, for example, in a row of dominos, one domino supposedly knocks the next one down, it pushes it down no more than it pushes it up. The effect one supposedly has upon the other depends on the relation of both to the gravitational system of which they are parts. In like fashion, seeing one key to the right of another on the piano depends upon the relation of both to a field of space. The organization of this field determines the position-value of each key.

The Problem of Temporal Unity. One of the most important consequences of the law of configuration is the change which it requires in our conventional notion of causation. This change has been mentioned under the law of least action. Traditionally, we think of cause and effect as sequences in time, but this idea is not consistent with the fact of temporal unity. Remember that objects in nature are never static; they are always moving if we select the right points of reference. They are units in time, therefore, as well as units in space. *A configuration is always a time-space whole.* For an illustration, return to the falling apple. The fall is a configurational phenomenon with respect to space; the path is determined by a total

gravitational situation, under the laws of determined action and least action. But the fall is also a temporal configuration, a unit in time from its beginning to its end. This can be seen from the previous statements that the gravitational system as a whole provides the beginning, the direction and the end of the fall before the motion of falling commences. The beginning is provided in the gravitational potential under which the apple hangs; without this potential the apple would fail to start. The system provides the line of flight and the remote end; the end must exist in the system before the movement will have a beginning.

All this means that the flight is conditioned *as a whole* by factors external to it. The first foot of the apple's fall does not explain the second, or the last. The beginning does not explain the end. The beginning, the course of the event, and the end, are conditioned simultaneously by the whole of which the entire line of flight is a part. This principle can be stated in the simple language that *an event in nature cannot be explained in terms of itself. And this is true no matter how long a time is required for the event to occur, and no matter how large or complex the object involved.* We are back to our original statement that a whole cannot be explained in terms of its parts. To explain a whole in terms of its parts is to explain an event in terms of itself.

The human body cannot be accounted for in terms of cells and organs; the square cannot be explained in terms of lines and space; the melody in terms of notes. Explanations run the other way. But remember that this applies also to processes that require time as well as space. For example, once the fall of a body has been selected as the event to explain, no one stage of the flight can be regarded as the cause of the next. Stages in a temporal sequence are temporal parts of temporal wholes. Suppose, now, that instead of a body falling, the growth of an individual from birth to death be taken as the event to be explained. Then it must be admitted that a person does not grow between the ages of two and three *because* he grew during the first year of life; or is he twenty-five at one time because he was fifteen at an earlier time. The *causes of growth lie external to the entire growth process, and growth through life is a single,*

configurational phenomenon, like the fall of the apple. It begins with a growth potential just as the apple's flight begins in a gravitational potential. It goes on in an environment of forces that corresponds to a gravitational field.

Definitional *versus* Dynamic Dependence. On the other hand the different stages of a temporal process have a *definitional dependence upon each other.* The apple, by definition, will not traverse the second foot of space until it has already traversed the first; the individual will not reach the third year of growth until he has completed two years. One does not finish a task he has never begun! There is progress, and each step in the progress, by definition, follows from its predecessor. One must be very careful not to confuse definitional and dynamic dependence. The first merely describes a situation; the other explains it.

The Problem of Future Reference. The law of configuration raises again the problem of *response to the future.* Under the law of least action it became evident that a moving body is conditioned in part by factors in the system that are ahead of the body in time. This same fact may be restated under the law of configuration. *The parts of a disturbed energy system are so adjusted dynamically that their behavior in the present actually depends upon relations that are to be effected in the future, namely, the relations of re-established balance.*

Energy is a curious phenomenon! Its laws are such that, apparently, it will not function at any given time *unless it can function in a certain way in the future.* The remote stage of an activity must be guaranteed before the first stage will commence. If the remote conditions are to be abnormal, so will the present conditions. This conception means that unless the growing individual can mature to a normal being, he refuses to develop normally. To the extent that normality *will be* deprived him, growth suffers now. Those who have growing personalities under their care should be able to detect the signs of maladjustment and disorder that mean, in advance, "I am an individual whose normal future is being deprived me, therefore, I am abnormal now."

Plan of the Text. The point of view of the text has now been outlined. It can be seen that a study of mental development is a study of an expanding and differentiating organism that we call a personality, a human configuration. This means that every act he carries out is a configurational phenomenon for it is a response of the organism-as-a-whole. This act is a *behavior-pattern.* The study of psychology is a description and analysis of this behavior-pattern. No matter what the pattern, it will be an organized response the first time it appears and throughout its development it will be organized. Considered as a movement-phenomenon it will be a *motor configuration.*

In order to secure the background with which to commence a study of mental development proper, and of the numerous motor configurations involved in learning, observations must first be made on the nervous system and the growth of the embryo. Here striking applications will be found of the principles that have been discussed throughout the present chapter. But this will not be enough to prepare the ground, fully, for an understanding of the child or of the learning process as investigated in adults. The learning process must be followed as we find it evolving in the animal scale from the one-celled animals to the apes. Here, learning can be observed in its simplest forms and best studied under controlled conditions. Especially is this true of investigations on animals whose brains have been partly or almost wholly destroyed. In these studies considerable light is thrown upon the physiological basis of learning, and evidence appears that demonstrates how living organisms form their habits.

With this background, the development of the learning process in the child will be examined in detail. There will then follow an intensive study of specialized types of learning found both in the child and in the adult. These learning processes will be analyzed in detail, then the major conditions studied that work for or against efficiency in learning. With this information the learning processes of the child in schoolroom situations and methods of instruction based on the laws of learning, will be investigated with the idea in mind of helping the prospective teacher prepare himself for effective work.

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CHAPTER III

THE EMBRYONIC NERVOUS SYSTEM IN RELATION TO BEHAVIOR

Pre-neural Organization

The Living Organism. The living organism, whether large or small, simple or complex, is a unified system of energy capable of growth and reproduction. This system of energy exists typically in the structural form of cells whose substance is called protoplasm. The simplest living organisms consist of a single cell. In the more complex organisms, like man, there are many kinds of cells which, all taken together, number at least into the billions.

Aside from growth and reproduction, living protoplasm exhibits the fundamental properties of excitability, contractility, conductivity, and rhythmicity, which differ in amount with the type of cell. In all living organisms these properties are expressions of dynamic relations existing between the organism and its environment, or between the organism-as-a-whole and its parts. But cells are not the basic features of the living organism. These are, rather, structurizations through which energy, existing as protoplasm, expresses itself and does its work. The fundamental processes of life are fields and systems of force forever being disturbed and regaining balance in accordance with the laws of dynamics. Unity and order in living organisms are names by means of which this sort of behavior is described. Unity and order are exhibited, at the biological level, in the growth of cells and systems of cells, organs and systems of organs. Unity and order at the psychological level are exhibited in phenomena which we call conscious behavior, processes of seeing, hearing, feeling, and thinking. But these processes also, like the cells, are ways in which energy expresses itself and finds equilibrium. In this case the energy most inti-

mately involved is that of nerve and muscle, and the growth processes are those of learning and mental development. In this case, still, we are dealing fundamentally with fields and systems of force that are forever being disturbed and are regaining balance.

Physiological Unity in Simple Organisms: The work of C. M. Child. Single-celled organisms, like bacteria and ameba, are completely integrated wholes. This integration takes the form of gradations or gradients in the rate of living of the tissue. These gradients are physiological field properties of the cell and are sometimes called metabolic gradients. Metabolism is a general term applying to the balance of chemical processes in living tissue, like the consumption of oxygen and the giving off of waste products.

In the single-celled organism there is a major or basic physiological gradient extending from its surface to its interior. That is, tissue at the surface possesses the highest rate of metabolism, and tissue in the center possesses the lowest rate. This is because forces like heat, light and pressure, impinging on the surface, incite the adjacent protoplasm to higher rates of physiological activity. Hence the gradient is sustained by a dynamic relation between the cell and its environment. Also within the organism there is a differentiation of tissue known as the nucleus, the vital center of the organism; and the nucleus exhibits a gradient of its own, a subgradient, having its own surface-interior grading of metabolism.

Proof of the Existence of Gradients. The fact that if forces of environment were not present there would be no gradient is indicated by the simple experiment of cutting the organism in two. The center of the organism, where physiological activities had been taking place at a lower rate, adjusts itself, now, to the immediate contact with external forces and takes on a surface-character. A new center forms as far away from the surface as possible. In other words, a new field of metabolism comes into existence with a new surface-interior gradient. Then we have a new organism or, in this case, two new organisms.

The existence of the gradient is demonstrated by various kinds of tests. If the single organism is stimulated at the sur-

face, its tissue responds to this disturbance, but the response is greatest at the surface and diminishes toward the interior. Moreover, tissue at the surface degenerates faster under the influence of poisons and is more subject to disturbing effects from mechanical injury, heat and electrical stimulation.

The fact that a single-celled organism is a complete unit becomes all the more striking when we reflect that it has no specialized structures like muscles and nerves. Yet, in principle, it does everything that the higher organisms do which have developed muscles and nerves. It is sensitive to light, to pressure, to mechanical contact, to chemicals, and to temperature, but its responses are primitive as compared with those of the higher animals.

Unity and Order in Complex Organisms: (1) Polarity. Complex organisms exhibit additional basic gradients. Not long after the animal egg is fertilized a gradient forms from the head to the tail region, with the highest rate of metabolism at the head-end and the lowest at the tail-end. Because it has higher potential energy at one end than at the other, the egg is *polarized.* Other kinds of fields, also, are polarized, as for example an electrical field represented by a battery with its positive and negative charges. Polarization indicates the direction in which action will take place within the field. Thus, when the tissues of the complex organism differentiate, each type becomes polarized; the gland cells are polarized to secrete in a certain direction, the muscle cells to pull on definite points of attachment on the bones and ligaments, and nerve cells to conduct impulses in definite directions.

(2) Physiological Gradients. Polarity is a dynamic differentiation within a field of force. One of these basic fields of force characteristic of animal forms is the head-tail gradient, technically known as the anterior-posterior gradient. (See Fig. 3.) These gradients are wholes that condition the activities of their parts. In relatively simple, multicellular animals, for example the hydroid polyp, that lives in the water, a section along the middle can be removed. The cut end that was originally nearest the head will grow a head, and the tail-end of the piece will become the tail-end of the new animal. The anterior-

posterior gradient conditions the growth processes that take place in the piece that is removed.

In the embryos of simpler animals, undeveloped tissue can be taken from the head and tail regions and exchanged. Then what would have contributed to a head grows into a tail and what would have contributed to the tail grows into the head, again an illustration of the law of determined action. There

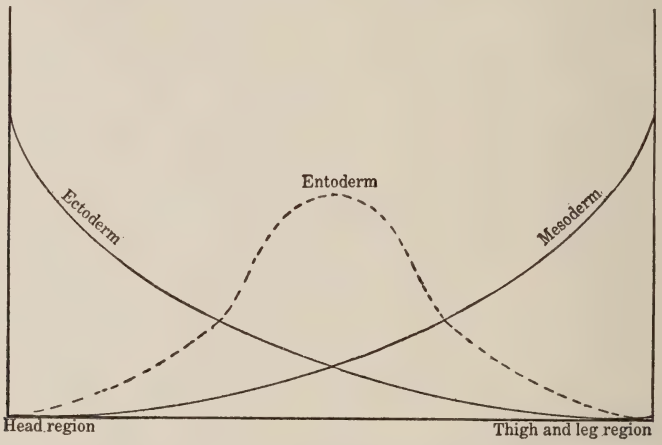

FIG. 3. SCHEMA SHOWING THE RELATIONSHIPS OF THE MAJOR PHYSIOLOGICAL GRADIENTS.

The distance of each line from the base roughly approximates the physiological rate of the tissue concerned.

are many ways, in fact, of demonstrating that unity and order in the complex organism express themselves in differentiations of major physiological gradients into subordinate gradients. When the energy of the gradients becomes so structured that their position and form are relatively fixed, they are called cells and organs. Their development follows the laws of individuation and field genesis. They emerge as local structures within a field of energy, acquire their properties (position and function) from this field and, as they emerge, constitute an organic whole. *They are interrelated as they emerge.*

(3) **The Ectodermal Gradient.** The anterior-posterior gradient in the embryo becomes the dominating characteristic of an outer layer of tissue, the ectoderm, that will eventually become the brain and spinal cord, nerves, sense organs and

skin. The brain and the spinal cord constitute the central nervous system. The largest and most complex part of this system develops at the anterior end of the gradient, the head. (See Fig. 4, part A.)

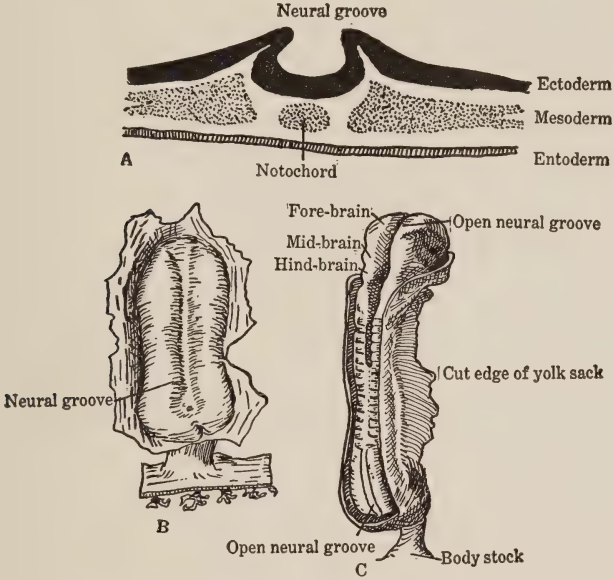

FIG. 4. DEVELOPMENT OF THE NEURAL GROOVE IN THE EMBRYO.

Part A. Schematic cross-section of an animal embryo before the neural groove has closed, showing the three major layers of tissue. Part B. Sketch of human embryo about twenty days old. Part C. Sketch of human embryo about four weeks old. Note how the groove is closing over and how the head end is enlarging. The contours of the fore- mid- and hind-brains are beginning to show.

(4) The Mesodermal Gradient. Early in the life history of the embryo another major gradient forms with its highest rate of metabolism in the posterior part, and lowest toward the anterior part. This gradient becomes the dominating characteristic of a middle layer of tissue, the mesoderm, that will become the musculature of the animal. The bulk of this musculature forms at the posterior end of the gradient, in the thigh and hind-leg region, where muscular metabolism is the greatest.

(5) The Entodermal Gradient. A third layer of tissue forms very early in the embryo's history. This layer, the

entoderm, becomes the inner lining of the digestive tract. Here there is a gradient of metabolism with its highest rate in the middle, tapering off toward both ends. The stomach and upper part of the intestines, where the bulk of digestion takes place, develop in the high region of the gradient.

These major gradients condition the time of development, the position, size and function of all organs and cells of the body. In embryonic growth, therefore, wholes are primary and parts derive their properties from the whole.

Development of the Nervous System. The animal embryo is at first a single, fertilized cell, formed by the union of an ovum, or egg, the female cell, with a spermatozoön, a male cell. This fertilized cell multiplies rapidly in the form of a spherical mass. In turn, the bulk of this spherical mass becomes an elongated thickening of cellular layers. At this juncture the three gradients, just mentioned, become differentiated and the three layers of ectoderm, mesoderm and entoderm come into existence. The first signs of a nervous system appear in a streak or groove in the center of the ectodermal thickening, and muscular tissue of the trunk develops in segments along the two sides of the nervous system. (See Fig. 4, part B.) It will not be necessary to follow these growth processes in their intricate detail. But typical cases illustrating the growth of the nervous system will be *necessary for a clear understanding of mental development.*

Origin and Growth of Nerve Cells. Upon microscopic inspection an organism appears to be merely a bundle of cells arranged in most intricate patterns. So evident was this fact that the cell was long regarded as the explanatory unit of the organism. This was the so-called cell theory, now abandoned in favor of the dynamic gradient theory. But since the gradients function through a cellular medium a knowledge of cells is important, especially of cells that specialize in conduction, such as the nerve cells.

A nerve cell begins, in the embryo, as a more or less column-shaped, microscopic structure. Masses of these cells develop in the walls of the neural groove along an axis from the head to the tail region, growth commencing first at the head-end of the embryo. The groove eventually closes over to form the

neural tube. The walls of the head-end of this tube thicken, fold over in an intricate fashion, and become the brain. The rest of the tube becomes the spinal cord.

Meanwhile, from each of the column-shaped cells in the spinal cord, two fibers extend out, one from either end. One of these fibers remains within the spinal cord; the other leaves the spinal cord for some part of the body. *The direction in which these fibers grow is conditioned by their dynamic relation to the field into which they penetrate.* The field, as we have seen, is a system of graded physiological stresses. Accordingly, the growth process of the fiber acquires direction just as the fall of an apple acquires direction. In the growth process, however, the underlying systems of stresses are more complicated.

Polarization of the Nerve Cell. The skin and muscles of the embryo are forming while this growth of nerve fibers is taking place. Two sets of fibers grow out from the spinal cord to the muscles, and another set goes to the skin. Of the two sets to the muscles one of them will eventually conduct nerve currents from the spinal cord to the muscles; the other set will conduct from the muscles to the spinal cord. Fibers that make contact with the skin will conduct from the skin inward. What, then, determines the direction of these impulses? Recall that in the organism there are pre-existing fields of force, the gradients. One of these fields includes the central nervous system and the skin; the other, the mass of muscle tissue. These fields are polarized in opposite directions, and, in terms of their polarization, determine the direction in which the nerve fibers will conduct, for they will conduct from the region of highest to the region of lowest stress within a particular field. Then a disturbance at the end of higher potential will release energy in the form of a nerve impulse, and the impulse will travel over the cell to the end of lower potential. The disturbance is known as a *stimulus*. The nerve impulse is a wave phenomenon, chemical-electrical in nature, which is set up by a stimulus acting on a sense organ, and, in warm-blooded animals, travels at the rate of about 120 meters per second. Evidence shows that a nerve impulse is probably a complex wave involving vibrations of different frequencies.

Even before the embryo can respond to an external stimu-

lus its field of energy is differentiated into skin and into muscle segments, and the muscle segments have their own subordinate field properties. In each segment the rate of metabolism is the highest in the center and lowest at the ends. The skin, also, has a very high rate of metabolism. In general, those fibers that grow into highest rates of metabolism in a particular gradient, that is, either toward the head-end of the nervous system,

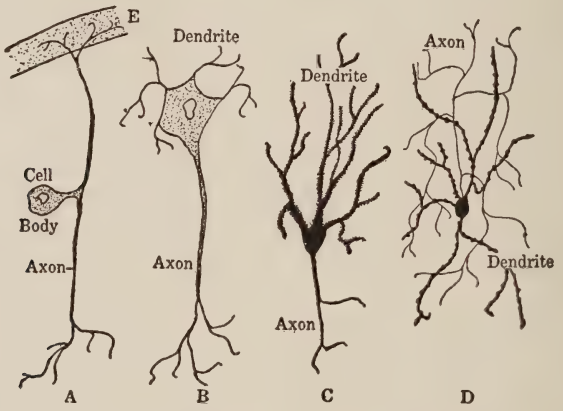

FIG. 5. SAMPLES OF TYPICAL NEURONS.

A is a bipolar cell of the type leading from the skin (E) to the spinal cord. B is a typical unipolar cell, such as motor cell leading from the spinal cord to a body muscle. C is a Purkinje cell from the cerebral cortex. D is a multipolar cell from the cortex. Adapted after Lickley.

toward the skin, or toward the highest rates of metabolism in the muscle segments, *become discharging fibers, called axons.* They discharge into muscle cells and glandular tissue. Those that grow into that part of a particular field having the lowest rate of metabolism *become receiving fibers or dendrites.* To them are attached the sense organs of the body.

Cellular Structure of the Nervous System. A typical nerve cell is called a *neuron.* It consists of a cell body and at least two fibers. The receiving fiber, or dendrite, is usually a very elaborate structure, branched like a tree. Generally it is fairly short. The discharging fiber, or *axon,* is relatively long, and less branched. Its branches are called *collaterals,* each of which ends, like the axon, in a tuft of fibers called an *end-brush.* (See Fig. 5.)

From an anatomical standpoint, the nervous system of animals is composed mainly of these cells, arranged in chains. At one end of the chain, the receiving end, there is a sense organ or end-organ. These are found in the eye, ear, nose, skin, and muscles. The chains form bundles, or nerves, leading in from the sense organs to the central nervous system. There they diverge, passing through the central nervous system in various ways, and out again in other bundles to the muscles and glands of the body. The external neurons of the chain conduct inward and are called *sensory neurons;* those that conduct outward are called *motor neurons.* The central links are *commissural* (bridge) *neurons.*

Between the axon of one cell in a chain and the dendrite of the next cell there is a relative break, or juncture, known as a *synapse.* The nervous system as a whole contains several billions of individual neurons, each with its branching dendrites and axons. The cell bodies are concentrated in various parts of the system known as nerve centers. When these centers are located within the central nervous system they are called *nuclei.* When outside of the brain or spinal cord, in some part of the body, they are called *ganglia.* In spite of the almost inconceivable complexity of the nervous system it is systematized under the laws of dynamics with equally as inconceivable an orderliness. It is a unified, 'fluid' field of energy, following the same laws of behavior that apply to electrical, atmospheric and other fields where there are no 'cells.'

The Beginnings of Behavior

First Movements of the Embryo: Coghill. The beginnings of behavior are to be found in the embryo, and here, also, evidence of the basic laws upon which an understanding of mental life depends. Researches on the salamander embryo, by Coghill,[1] have yielded most valuable information in this direction. *The first movement of the embryo is a mass movement of the organism as a whole.* In the salamander this movement occurs by the time the animal is thirty-six hours old. But even

[1] Coghill, G. E., *Anatomy and the Problem of Behavior.* New York: Macmillan, 1929.

earlier than this there is a period in which the muscles behind the head have matured to the extent that they will contract, before the muscles farther down the trunk are ready to function. Thus, as the animal matures, the extent of the mass movement increases tailward. Each movement begins in the head region and extends toward the tail as a wave of contraction, or flexion.

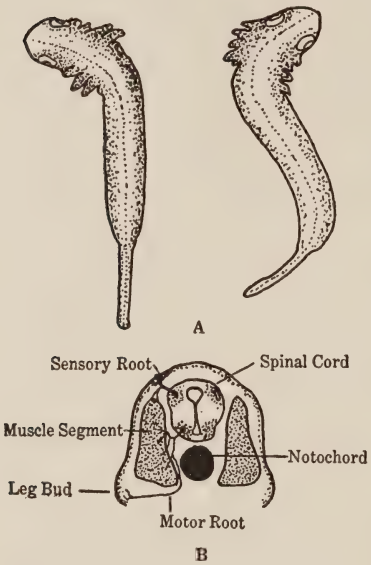

FIG. 6. SALAMANDER EMBRYO.

Part A. Figure at the left shows simple flexure movement; figure on the right shows the 'S' shaped coil. Part B. Cross-section of embryo in region of fore-legs. Note how the sensory fibers (root) branch and go both to the end of the muscle segment and to the skin. The motor fibers branch, certain of them going to the trunk muscle and others to the leg bud. This typifies the unity of the nervous system at an early stage in the life of the embryo. Adapted from Coghill, *Anatomy and the Problem of Behavior,* Macmillan, 1929. By permission.

The nervous system involved in this activity is an elaborate network of cells in the spinal cord that sends out its fibers to the muscle segments of the trunk. In embryos, lower in the animal scale than the salamander, the movement just described occurs before the sensory neurons have become joined to the motor neurons by commissural cells in the spinal cord. Hence the movement must occur as a result of internal stimulation. The contractions alternate from one side of the body to the other. Contraction on one side only draws the animal into a coil, but before this flexion is over, another begins on the opposite side, coiling the animal in the opposite direction, resulting in an 'S' shaped posture. The 'S' type of movement becomes the basis of locomotion both in the water and on land. (See Fig. 6, part A.) While all this is taking place, the embryo is still maturing as an integrated whole, but as yet it has no legs.

An examination of the nervous system at this period in the

embryo's development explains why the movements involve the organism as a whole. *First,* there are no differentiated nerve centers exerting special control over local parts of the external musculature. *Second,* motor fibers leading from the spinal cord to the trunk muscles branch to more than one segment, overlapping their branches to a single segment. An isolated innervation (stimulation, excitation) of a single muscle segment is therefore impossible.

Emergence of Local Movements. Obviously no local movements can be made until groups of muscles develop that are supplied with relatively independent parts of the nervous system. Among the first of such groups of muscles to develop in the salamander are the arms or fore legs, which mature in advance of the hind legs. Curiously, before the arms make their first appearance as protuberances from the side of the body, nerve fibers, later to attach themselves to the skin and muscles of the arm, have penetrated beyond the trunk muscles as branches from the fibers that have already made connections with the trunk. These branches are ready to attach themselves to the muscles of the arm as soon as the latter are ready to function. It can be seen from this situation that the arms can move only as a part of the total body movement. (See Fig. 6, part B.) Later, as nerve centers in the spinal cord develop, fibers grow out to the arms directly, but the center differentiates under the control of the total nervous system, consequently the local movements of the arms *are never independent.* The arm will by this time contract upon stimulation of the hand. As the hind legs develop the same growth procedure and type of control exerted by the whole over its parts is repeated.

Character of Local Movements. A 'local' movement produced by stimulation of the part in question has been called a *reflex.* It is defined as a stereotyped contraction of an isolated group of muscles. Having once observed these local movements, an investigator might be led to suspect that these were the units out of which complex movements of the organism were composed, *but this is not the case. The 'local' reflexes do not combine. Once they differentiate from total body movements they always remain differentiated.*

Character of Complex Movements. Walking is a typical complex movement. In order to understand how these movements are acquired one must think back to the original mass action of the animal. A wave of contraction passes down one side of the body, and shortly behind it another wave passes down the opposite side, both from the head region tailward. At this time in the development of the embryo, these waves of flexion extend into the arms and legs so that the arm on one side moves one instant and the leg on the same side moves an instant later. But just as the contraction of the left leg occurs the flexor movement on the right side of the body has passed into the arm on that side. Thus the right arm moves about the same time as the left leg. By the time the right leg contracts, another flexion has begun on the left, carrying with it a contraction of the arm. In this general way the movements of arms and legs are synchronized. When contractions of local muscle groups differentiate out of total leg and arm movements they are organized, as they emerge, with respect to the total body movement. Thus, even after walking movements are fully acquired, they are still mass actions, highly complex and differentiated to be sure, but still movements of the organism-as-a-whole. All of this comes about as a consequence of growth or maturation. No experience, in the customary sense of the term, is required.

Individuation of Specialized Movements. We have seen that walking movements are not organizations of reflexes, for reflexes do not integrate. Neither are any other co-ordinations the products of discrete and independent movements. Take, for example, movements of the fore arm, hands and fingers. When the arm is capable of moving, within limits, independently of the body, *it must first move as a whole.* There are no separate contractions of the fore arm, hand and fingers. These must wait upon further maturation in the nerve supply of the arm. Then the movement differentiates with the elbow as the dividing point so that the fore arm can be innervated as a whole; but still there are no separate hand or finger movements. Then hand movements individuate from fore arm movements, and finally finger movements from total hand movements. In each instance the development is from

the whole to its parts, through individuation. Thus it is that separate movements of the fingers, once made, do not combine into complex activities of the hand. Once separate, they remain so. Instead, co-ordinated movements of several fingers at once must emerge as a total performance from hand or arm movement.

A still more striking example of individuation is found in the movements of snatching food with the mouth. By the time the salamander embryo has developed fairly sturdy arms, it can see. Present it with a fly and it will lunge toward its prey with mass action of the head, neck, shoulders, arms and trunk. But this is before jaw movements have emerged. The animal attacks its prey before it can make the movements of seizing it! Shortly, the jaw movements individuate from the mass action. Now present the stimulus and the salamander will attack and seize it. But this is before chewing and swallowing movements are possible! Again there is growth from the whole to its parts and nothing on the order of initial, discrete movements appearing first and combining later.

Summary of Embryonic Behavior

The Laws of Embryonic Development. It is obvious without further discussion that the organismic laws presented in Chapter II apply to embryonic development. *First,* the law of field properties is illustrated by physiological gradients which are polarized fields of force involving living tissue. Major metabolic gradients are more than the sums of the subordinate gradients formed by the specialized structures of the organism. And it is quite as evident that the same law holds also for the movements of the organism. *Second,* the law that the properties of the parts are derived from the whole is demonstrated throughout embryonic growth. The positions and functions of different organs are derived from the field properties of the whole, even to the direction in which single nerve cells will conduct their nerve impulses. *Third,* the law of determined action is illustrated in the control exerted by the physiological gradients over the *direction* of local growth processes in all parts of the organism. The anterior-posterior gradient conditions the

growth of highly specialized sense organs and nerve centers in the region of the head; the mesodermal and ectodermal gradients, together with the surface-interior gradient, guide the penetration of nerve fibers into the various parts of the body; subordinate gradients in the muscle segments direct the attachment of sensory fibers to the ends of the segment and of motor fibers to the center of the segment.

Fourth, the law of individuation was mentioned several times in connection with the specialization of finer movements out of grosser ones, with the original movement a mass action of the organism-as-a-whole. *Fifth,* the law of field genesis is obviously exemplified in the expansion and differentiation of the organism as a complete unit from the single cell to the adult. *Sixth,* the law of least action is evidenced in the manner of control exerted by the whole over its parts. The growing nerve fibers find their way to their destination over the shortest route in time, commencing in a region of high potential and terminating in a region of low potential. The emergence of any part within the whole is a process of reaching a remote end set up, before growth commences, by pre-existing gradients. *Seventh,* the law of maximum work is supported by operative experiments where segments of an animal are exchanged. The organism as a whole maintains its organization by overcoming the disturbance. In fact, any process of recovery from injury illustrates the particular point emphasized by this law, that an energy system resists disintegration by adjusting itself, as a whole, to a disturbing influence. It is illustrated each time the organism as a whole responds to a stimulus impinging upon a part. And *eighth,* the law of configuration comes to light, again, in the organized character of every adjustment either in a part of the animal or of the animal as a whole. The gradients characteristic of single-celled animals are an organized response of the total organism to a total pressure-pattern exerted upon the cell from the environmental medium in which it lives. Alter these patterns and the organism-as-a-whole adjusts its growth processes accordingly. A process of growth, say of a nerve cell, is a temporal unit conditioned by a total situation, namely, a gradient of potentials surrounding it. This gradient, through

its own polarization, supplies at once the beginning, the direction and the end of the growth process.

The Matured Nervous System

A General View of the Adult Nervous System. From an anatomical standpoint, the nervous system is composed of elongated neurons arranged end to end in the form of a circuit between the sense organs of the body (receptors), through the spinal cord and the brain, to the glands and muscles. In general the functions of this circuit are to connect all parts of the organism with the outside world and to bring all parts of the organism into relationship with each other. This latter function is accomplished through an organized individuation of parts from dynamic wholes.

Sensory fibers converge from the receptors of the body into small bundles, already defined as nerves, then into larger ones, leading from the body into the spinal cord over spinal nerves that enter the cord at regular intervals (dorsal roots). Sensory fibers from the head region and part of the neck enter the brain, directly, over cranial nerves. Motor fibers also extend over cranial nerves from the base of the brain to the muscles of the head; from the spinal cord corresponding fibers find their exit through ventral roots and from hence to the muscles of the trunk, arms and legs. A single large nerve, like the sciatic in the leg, is composed both of sensory and motor fibers numbering into the hundreds of thousands. All nerves, external to the central nervous system, are white in appearance.

White material (white matter) of the nervous system, whether or not external to the brain and spinal cord, is composed of fibers, each covered with a white, fatty sheath, the *myelin* sheath. Within the brain and spinal cord are nuclei composed of *grey matter,* that is, dendrites, cell bodies and unmyelinated axons. All synapses are, therefore, in the grey matter, since the synapse is the membranous juncture between the end-brush of one neuron and the dendrite of another.

The nervous system is bilateral; sensory nerves from the left half of the body find their way to centers in the right half of the nervous system (with certain minor exceptions), and

motor nerves originating in the left half of the nervous system ultimately connect with muscles on the right side of the body.

Gross Anatomy of the Brain. The brain as a whole is called the *encephalon.* It is conveniently divided, for descriptive purposes, into sections, the name for each section signifying its position with respect to the whole. Commencing at the forward end there is, first, the *telencephalon,* the endbrain, con-

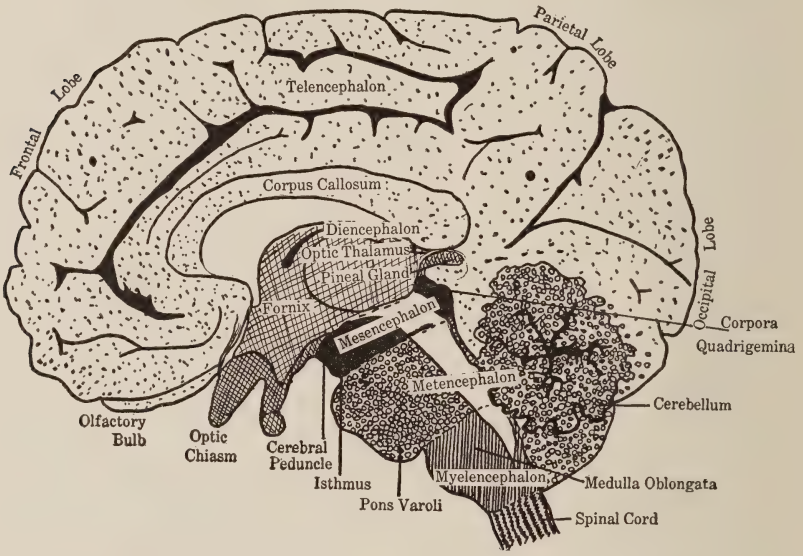

FIG. 7. MEDIAN SECTION THROUGH HUMAN BRAIN.

sisting of the cerebral hemispheres. These hemispheres are conspicuously divided by a deep crack or fissure extending forward and back through the center of the brain. Inside the hemispheres are narrow, winding canals called the *lateral ventricles* which are filled with cerebro-spinal fluid. Then, there is the cortex, two to four millimeters thick, together with fibers connecting various parts of the cortex with one another in the same hemisphere, and commissural fibers connecting one hemisphere with the other over a bridge known as the *corpus callosum.* Proceeding toward the base of the brain, there is, second, the *diencephalon,* or interbrain, which consists of the *thalamus,* a very complex sub-brain, at one time in the course of evolution the highest brain that had developed. (See Fig. 7.)

Still farther down there is the third major section, namely, the *mesencephalon* or midbrain. Below the midbrain is the fourth division, the *metencephalon* or hindbrain, of which the *cerebellum* is the most conspicuous part. It contains also a bridge of fibers called the *pons varoli.* These fibers connect one side of the cerebellum with the other. Beneath them are several nuclei. Fifth, there is the *myelencephalon* or afterbrain, which is composed largely of the *medulla oblongata.* It contains: (1) various nuclei having to do with certain receptors and muscles of the head, and (2) the 'vital' center which controls breathing and heart action.

The Spinal Cord. The spinal cord receives fibers from the receptors of the body; sends fibers to the muscles, and connects with the brain centers above. The cell bodies of the entering sensory cells lie just outside the spinal cord. A typical cross-section of the cord would reveal a mass of grey matter on the inside and a layer of white matter on the outside. The grey matter consists of dendrites, cell bodies and axon terminations. It joins one level of the cord with another and links the higher brain centers with motor cells leading to the muscles. It also connects sensory and motor neurons at all levels of the cord, bringing into relation receptors and muscles on the same and on opposite sides of the body.

The white matter consists of ascending and descending fibers arranged in tracts. The ascending or sensory tracts carry impulses from the skin and muscles of the body to the lower parts of the brain and the cerebellum. The descending or motor tracts are composed of fibers from the cerebral cortex that have converged through the midbrain and medulla on their way down to the cord. Fibers from these tracts terminate in the ventral grey matter of the cord and connect with motor neurons to the muscles.

The Lobes and So-called Areas of the Cortex. The cerebral cortex is richly supplied with folds or *convolutions* (gyri) with deep recesses between them known as *fissures.* These fissures and convolutions serve as convenient points of reference in a description of the cortex. Also, for purposes of reference, the cortex is divided into lobes. Anterior to the *precentral fissure* (fissure of Rolando) is the *frontal lobe;*

posterior to the same fissure and above the *central fissure* (Sylvius) is the *parietal lobe;* at the extreme posterior portion is the *occipital lobe* and below the central fissure, on the lateral surface of the cortex, is the *temporal lobe;* on the ventral surface where the hemispheres fold under, is the *hippocampal lobe.* (Fig. 8.)

The hippocampal lobe is the main entrance of the olfactory (smell) and gustatory (taste) tracts into the cortex-as-a-whole;

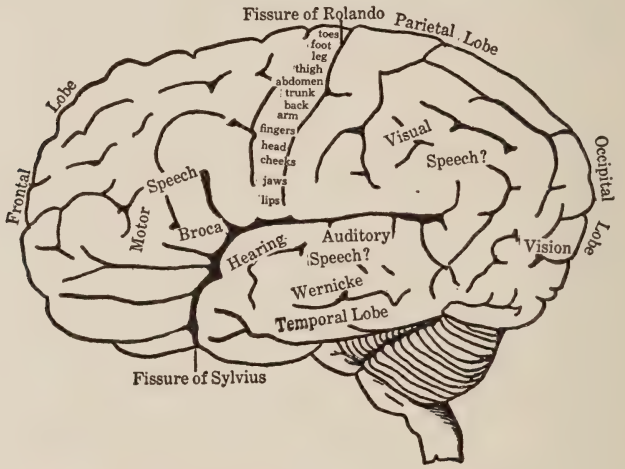

FIG. 8. LATERAL VIEW (left) OF THE HUMAN BRAIN.

the temporal lobe contains the threshold of the auditory (hearing) tracts into the cortex; the occipital lobe contains the threshold through which enter nerve impulses from the retinas. In the parietal lobe, immediately posterior to the precentral fissure, is the threshold through which tactual (touch), pain, temperature and kinaesthetic (muscle sense) fibers enter the cortex. Immediately anterior to the precentral fissure is the so-called motor area, the exit of motor routes from the cortex to the base of the brain and spinal cord.

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CHAPTER IV

FUNCTIONS OF THE ADULT NERVOUS SYSTEM

Gross Functions of the Brain

Size of the Brain as a Condition of Behavior. The evolution of the brain in mammals was characterized chiefly by a development of the telencephalon. Not only did the cortex increase in size, but the cortical neurons developed more branches and a greater number of long, connecting fibers. The increase in size of the cortex was made possible by an enlargement of the skull and by an increase in the number of fissures and convolutions. Long fibers were especially important in the advance of nerve integration from simple to complex types, for they not only brought remote parts of the organism into relationship with each other but placed them under the control of a central organ.

The size of the brain, however, is not alone a measure of intelligent behavior. Not only does the size of the brain increase as we proceed along the animal scale, but it increases as body weight increases. This latter fact may be interpreted to mean that the greater the number of muscle and skin cells the more brain cells are needed to make co-ordinated movement possible. Likewise, the greater the surface of the body the greater the number of pain, pressure and other receptors, all presumably represented by patterns of cortical cells. Moreover, since auditory, visual, taste and smell fibers must co-ordinate with all parts of the body, more space is needed for the necessary network of tracts. Support for this general view is found in the fact that in the whale and the elephant the cortex is elaborately convoluted, thus giving it more bulk and surface area.

While the whale has the largest brain of any of the animals, it is the smallest in proportion to the size of the body. There-

fore, size of the body is obviously only one factor among the many that correlate with the size of the brain. The brain in man is heavier in proportion to his body than in most of the other animals. This difference in proportion might be taken to measure the extent to which size of the brain conditions degree of intelligence in the species, but we are prevented from drawing such a conclusion by the fact that the monkey, seal and squirrel show approximately the same high ratio. *We may assume that the agility of the animal is correlated with the ratio of brain to body weight. That is, the more agile the animal the more brain material is needed per unit of body weight in order to make possible a great variety of delicate muscular co-ordinations. Not only is variety a factor demanding brain cells, but also speed and precision of movement. All of these are found in the monkey, squirrel and seal.*

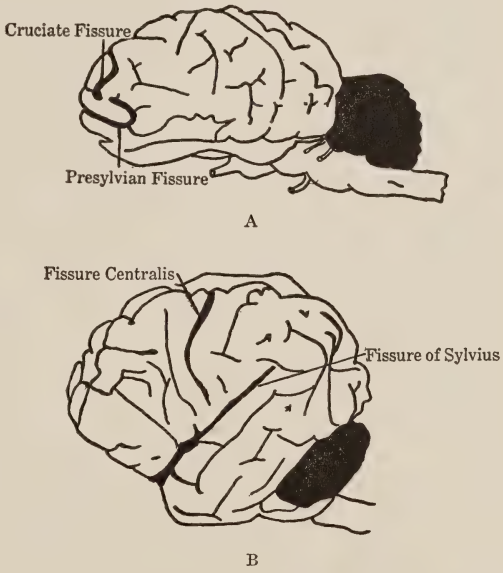

FIG. 9. LATERAL VIEWS (left) OF SHEEP (above) AND CHIMPANZEE (below) BRAINS.

Note the forward position of the pre-central (Cruciate; Rolando) and central (Presylvian; Sylvius) fissures in the sheep, and their central position in the chimpanzee. Adapted from Tilney, *The Brain from Ape to Man,* Hoeber, 1928.

The Brain Patterns of Primates Contrasted with Pre-Primates. The evolution of intelligent behavior is correlated with the growth of a particular type of brain pattern. If the brains of the pre-primates (animals lower down in the scale than lemurs and monkeys) are examined it will be noted that in each instance there is only a small frontal lobe. (Fig.

9.) The fissure that corresponds to the central fissure lies very close to the forward end of the brain (frontal pole). Even in the most complex of all pre-primate brains, those of the horse, elephant and whale, this fissure is still far forward. The precentral fissure has migrated back toward the central region, but not far, and is still a minor fissure. Once the direct ancestral line of the human being is reached, however, the cerebral pattern shows a marked change. The frontal lobe begins suddenly to develop. In its evolution three striking events take place. *First,* the frontal lobe enlarges and submerges the area that shows on the lateral (side) exterior of the pre-primate brain. *Second,* with the enlargement of the frontal lobe, both the central and precentral fissures deepen and migrate backward. *Third,* the occipital lobe increases in size and covers a large portion of the cerebellum. Finally, all over the cortex convolutions and fissures become more numerous, giving more space to grey matter. These progressive changes may be observed, starting with the lemur, the most primitive of the primate line, and passing up through the lower monkeys to the ape and gorilla, the gorilla having the most highly developed of anthropoid (man-like) brains below man.[1]

Summary of Functions of the Brain. It is incorrect to speak of specific functions located in particular parts of the brain, for in all modes of behavior, the brain-as-a-whole is involved. This does not mean, however, that during the execution of a particular performance certain parts do not expend more energy than other parts. The brain is a system of energy-gradients or gradients of potential, as extensive as the brain itself. There are no 'seats' of vision, hearing, and motor control. Each part functions in the light of, and with, the whole.

In reading the following summary, therefore, the different parts of the nervous system must be regarded, like a leg movement in walking, as a local differentiation of a total pattern, having no significance except in terms of the whole.

Spinal cord:

Transmits to brain from sensory neurons.
Transmits from brain to muscles.

[1] See Tilney, F., *The Brain from Ape to Man.* New York: Hoeber, 1928.

Connects different levels of the body.
Connects one side of the body with the other.
Originally the organ of such conscious behavior as took place in the higher invertebrates and lower vertebrates.

Medulla:

Co-ordinating center of tongue movements in eating and speaking.
Co-ordinating center of throat muscles in speech.
Co-ordinating centers of compensatory 'reflexes.'
Co-ordinating center of the vagus nerve, controlling breathing and heart action, digestive secretions and movements of the alimentary tract. Integrates stomach and salivary glands with sight and hearing.
Connects the head and body with the cerebellum.
Controls secretions of mucous membranes of the head.
Contains centers for co-ordination of muscles in deglutition, coughing, hiccoughing, vomiting.
Conducts to the cord from midbrain and thalamus.
Conducts motor impulses passing down from cortex to tracts of the cord.
Receives from the cerebellum and relays to the cord and cortex.
Transmits all manner of local impulses.

The pons:

Aids in prehension and mastication of food.
Aids in control of facial expression.
Controls lateral movements of the eyes.
Receives and integrates equilibratory impulses from semicircular canals (organs of equilibratory sense, near organ of hearing).
Receives and integrates impulses from the ear.
Aids in control of throat co-ordinations in speech.
Contains center for conjectival, gum, lip and pinna 'reflexes.'
Connects cortex with the cerebellum.
Relays to cerebellum from numerous sources above and below.
Connects midbrain with the cord.

The cerebellum:

Supports tonus of skeletal musculature.
Maintains balance and bodily attitudes.
Receives from organ of equilibrium.
Receives from practically all parts of the nervous system and sends to practically all parts.
An adjunct to the motor functions of the brain.

Midbrain, including corpora quadrigemina:

Controls many eye-motor co-ordinations.

Contains primitive visual and auditory centers.
Connects cerebellum with many other regions of the nervous system.
Relays visual and auditory impulses to the cortex.
Concerned with numerous eye and ear connections with the cortex and the cord.

Thalamus:

Contains about 20 nuclei, relaying visual, auditory, tactual, kinaesthetic, pain and temperature impulses to the cerebral cortex.
Also contains motor centers having to do with emotive behavior.
Connects with the hippocampus.

Cerebral hemispheres:

Major portion necessary for all forms of conscious behavior. The last of a series of brains evolving in the course of animal evolution. The spinal cord, and ganglia corresponding to the medulla and cerebellum, are the oldest of the evolutionary brains. The midbrain and thalamus come next. Superimposed upon the thalamus are large nuclei, beneath the cortex, representing brains older than the cortex itself. These are the lenticular and caudate nuclei.

Experiments on the Nervous System

Lashley's Experiments. Lashley [2] has performed elaborate experiments on the behavior of rats and monkeys under a great variety of experimental conditions. He found that, in general, the larger the brain injury artificially produced by cutting or burning the cortex the more behavior was impaired. Simple problems like the threading of easy mazes were still solved whether the lesion was in the motor or the visual area. In one experiment he trained rats to choose food from an illuminated rather than a darkened alley. Then he destroyed different areas, including the visual. The habit disappeared only when the visual area was destroyed; but relearning was possible. Later he destroyed the visual areas in a number of animals before they acquired the discrimination habit. After they had learned the task he explored the remainder of the cortex by a second operation in an effort to discover what part, if any, had

[2] Lashley, K. S., *Brain Mechanisms and Intelligence.* University of Chicago Press, 1929.

assumed the visual function. That is, by destroying different regions in different rats he expected to find the area, if there was one, that took over the lost visual function, for presumably the rats in which that particular area was destroyed would lose the habit again. But all of his rats were still able to solve the problem; no particular area seemed to be the necessary one. *Only when a certain maximum of tissue was destroyed was the habit lost and it made little or no difference where the lesions were.* In still later experiments he taught rats to recognize fairly complicated visual figures in the course of obtaining food. Then, when he produced sufficient lesions in the visual area, discrimination of form was destroyed when it was not destroyed by lesions of similar extent elsewhere.

Thus far his experiments indicate that while, under the existing conditions, one area may be more active than others in the performance of a given act, that area can in no way be regarded the *seat* of a specific function. Instead, the brain always functions as a whole, but in carrying out a given performance gradients of nervous activity extend across the cortex, with the high region of the gradient in the area receiving the types of stimulation 'most important' for the performance in question. But again the functioning of this area, or part, depends upon its dynamic relations to the whole. For example, a complex visual habit could not be executed if all of the cortex except the visual area were destroyed; neither could it be executed when the area itself was sufficiently disturbed. The more difficult the performance, the more active the whole cortex, and perhaps the steeper the gradient from one particular part of the cortex to another.

A different study by the same author showed that visual and motor habits did not necessarily depend upon the motor areas of the frontal region. The performance of one particular rat in this experiment is noteworthy. The rat was a small female, trained to select food from the brighter of two alleys. Ninety trials were required in the original learning, prior to the operation. Then the frontal areas were transected and the caudate nuclei were destroyed by cauterization. During the first week after the operation the animal was unable to walk except in six-inch circles and could not make her way through the discrimi-

nation box. Nine days after the operation the disturbance had cleared sufficiently to allow walking in a straight line, but when she attempted to change her direction she was obliged to pivot. About this time she was given tests in the discrimination box in order to discover if the habit had persisted. She was still unable to make a left turn, *but whenever her position in the box required a 90-degree turn to the left she pivoted 270 degrees to the right in order to reach the goal.* A glance at Fig. 10 shows one of her simpler routes. Notice that *in order to reach the food she rotated to the right three times.*

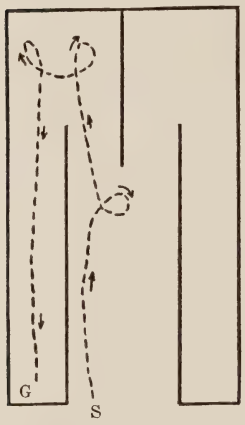

FIG. 10. PATH OF LASHLEY'S RAT. For Explanation see Text.

In his work on the Cebus monkey, Lashley discovered that destruction of the motor area did not permanently affect the learning process. It was evident, therefore, that the motor area was not the exclusive 'seat' of acquired movements. The first effect of the operation was a paralysis, but after recovery, the learned movements took place with equally as good co-ordination as before, only with less force and with greater susceptibility to fatigue. Evidently after the operation the animal lacked a sufficient mass of nerve impulses to maintain normal muscular activity. In other words, for normal behavior there is required a cortical 'facilitation' of movements whose direction and complexity are controlled, not by the motor cortex as such, but by whatever total pattern of nerve tissue there is, provided a certain minimum is available. The motor cortex, when present, yields the additional amount of total energy to give vigor and stability to the performance, but is not necessary for effectual co-ordination unless the performance is sufficiently difficult to require large masses of grey matter.

Effect of Lesions in the Spinal Cord. Lashley and Ball [3] recently trained a number of rats to make perfect per-

[3] Lashley, K. S., and Ball, J., "Spinal Induction and Kinaesthetic Sensitivity in the Maze Habit." *J. Comp. Psy.*, 1929, Vol. 9, 71-106.

formances in a maze with eight blind alleys. Then, by an operation, lesions were produced in the spinal cord. There were in all ten operated subjects. The operations in every case resulted in disturbances in motor co-ordination, and in some instances, the animals seemed to have lost their 'feeling' of muscular movement. After recovery, some rats with each type of lesion were able to traverse the maze without making significant errors. By running the rats in absolute darkness, visual cues were eliminated; by keeping the maze thoroughly washed, smell cues were eliminated; and the character of the maze was such that touch and auditory cues, according to Lashley and Ball, could not have functioned in the place of cues from the movements of the muscles themselves (kinaesthetic cues). The investigators concluded, therefore, that the maze habit is not a series of reflexes but that a central 'mechanism' of some kind is capable of guaranteeing an integrated sequence of movements in the absence of sensory cues, once the movements have been learned. The central mechanism would seem to be the 'whole' that conditions the activities of its parts.

This investigation points to the conclusion, first, that motor impulses from the brain to the muscles of the body found their way over other routes than those previously supposed to be required. The descending motor tracts are used normally (probably along with all others, also) because they are anatomically the most direct, not because they are the only possible, routes. The investigation indicates, second, that when the most direct routes, anatomically, are destroyed, sensory impulses still travel over other routes to destinations in the cortex. This they probably did anyway, although to a less extent, prior to the operation.

The Monkey and the Latch Box. In one of Lashley's experiments the left arm and hand of a Cebus monkey were paralyzed by a brain operation on the right cortex, then the animal was trained to open a latch box with its right hand. When the movements had been learned the monkey's right hand was paralyzed by a corresponding operation on the left hemisphere. Then, after waiting for the right hand to recover partially, the animal was given the latch box again. Meanwhile, the left hand had completely recovered. Confronted with the

latch box the monkey fumbled clumsily at the catches with his right hand but could make no progress. *With no random movements, he attacked the box with the left hand, and successfully opened it.* There was an almost perfect 'transfer' of the performance to the hand which had been paralyzed during the original learning.

This experiment has an extremely important bearing upon theories of brain functioning. There is a strong tradition, based upon the mechanistic custom of reasoning from parts to the whole, to think of a learned performance as the result of pathways in the nervous system, opened through use. The latest version of this theory involved the synapse. The opened pathway was described as a reduction of resistance to nerve currents after the latter had repeatedly passed through the synapses. *Notice that in this experiment, however, the synapses that, in terms of the old habit theory, required opening through exercise or repetition, had been destroyed or rendered functionless by the operation. The facts of this experiment, and many others, demolish the synapse theory of learning, for synapses never before used in the execution of particular motor co-ordinations function perfectly the first time.*

Irrelevance of the Use Theory of Pathways. The reason for this is not hard to understand in terms of dynamics. Recall how the apple finds its way to the ground. It has not been over the route before, yet there is no random activity; and it makes no difference where the apple is; it may be in England; it may be in Africa. An air current flows from one part of the country to another, without having done so before. An electric current flows from a region of high potential to a low one, without having sought its way by trial and error. In all dynamic fields, differentiated into high and low potentials, movements take place in terms of least action over the most direct routes in time from the high toward the low stress. In a scientific sense there are no random or trial and error performances in nature. Brain functioning is no exception. Whether a nerve current will travel in one direction or in another depends not upon whether synapses have been exercised, but upon the dynamic relations between a synapse and surrounding potentials. When there are areas of high and low potential, respectively,

behind and in front of a synapse, nerve impulses will traverse the synapse, and as easily the first time as the last.

In case of the Cebus monkey, the original learning involved an alignment of potentials in the nervous system that directed specific movements of muscle groups toward definite ends, or goals. The goals correspond to the positions of low stress. Once the system of potentials is formed and the organism is under tension toward a goal a whole is conditioning the activities of its parts. The nerve routes to and from the left hand, in case of the monkey, were as well organized with reference to the goal as were the routes to and from the right hand. The monkey could have used either foot in opening the box had it been necessary!

Koffka's Illustration of Organismic Principles: Eye-Movements. It can be shown that at a certain period in his development, an infant will follow a moving light with his eyes, without practice, and without making random movements. Suppose that, with respect to the infant's head, a light is brought into the position *S*. (Fig. 11.) He turns his eyes toward the light and follows its movement to the position *T*. Then suppose that the light is placed in the initial position *S′* and moved to *T′*. The situation is quite different, for the eyes are in a different initial position. When focused upon *S′* the muscles on the left side of the eyes are relaxed and on the right side they are contracted; when the eyes are focused upon *S*, the situation is reversed. Moreover, different retinal patterns are stimulated in the two instances. This is because the light reaches the eyes from different angles and does not fall on points on the two retinas that exactly correspond. In short, there is nothing whatever in common between these two movements, or any other two, except the distance traversed by the eyes. The balance of muscle tensions during the movements is entirely different in any two cases;

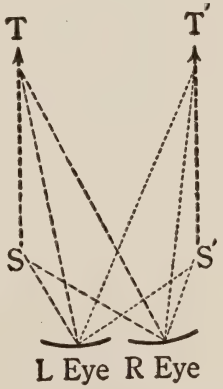

Fig. 11. Schematic Representation of Eye-movements. For Explanation see Text.

therefore, any two sets of stimulation coming from the muscles differ from one another. A mechanical explanation of these eye-movements would presuppose an infinite number of preformed and 'experienced' pathways, a logical absurdity and a physical impossibility. If one were to assume that the infant must learn each movement, through a random, trial and error procedure, he would never learn to move his eyes because he never makes two sets of eye-movements exactly alike.

A theory is required which will explain equally well any one of these unnumbered movements, but the solution is no more difficult than the explanation of falling bodies. Eye-movement is controlled by the dynamics of the field that involves the entire optic system, the retina, eye muscles, sensory nerves, motor nerves, and the brain. An important factor in this field is a gradient of sensitivity that extends across the retina. The retina contains a region of highest sensitivity in the center, or fovea (the spot of clearest vision), and a region of lowest sensitivity around the margin, or periphery. There is a fovea-to-periphery gradient. Let a light be exposed to the periphery of the retina. It will be seen out of the corner of the eye. The light is the point of strongest stimulation in the visual field. When the point of strongest stimulation fails to fall upon the point of highest sensitivity in the retina the optic system is disequilibrated, that is, put under tension. This tension demands a return to equilibrium through eye-movements. Eye-movements in any other direction than toward the strongest stimulus in the visual field would be away from, rather than toward, the establishment of equilibrium in the optic system. *Thus the movements of twelve pairs* (for each eye has six pairs) *of muscles are simultaneously given direction in terms of the conditions for least action.* The fovea-to-periphery gradient is the dominant directing factor. Eye-movements occur so that the light will travel across the retina, along the gradient, not against it. Here, then, is another case of a whole conditioning the activities of its parts, just as a gravitational system conditions all movements within it. Any eye-movement made away from the strongest stimulus in the visual field can easily be explained in terms of a different total system of stresses, having the optic system under control, and giving to the stimulus a greater

energy-value than the one intrinsically the brightest. Such a situation would be illustrated when a person, walking along the street, would have turned his eyes toward a bright electric sign except that a growling dog dashes toward him. The energy-value of the stimulus, a dog in this case, would be greater than the value of the electric sign.

Lack of Organization Among Reflexes. A reflex is defined as a stereotyped contraction of a given muscle group. Tap a spot on the leg, just below a person's knee, and the *patellar reflex* is elicited; strike the tendon above the heel and the *Achilles reflex* is elicited. *Such performances as these are not the units of muscular co-ordination. Coghill showed that reflexes in the embryo do not combine to form complicated movements.* The same principle that, once reflexes have emerged from the mass activity of the organism, they always remain emerged and separate, was demonstrated indirectly years ago by Blanschko's experimental frog. The frog's cerebral hemispheres had been removed, yet when certain spots on the skin were irritated by a pain-stimulus, reflex contractions of these parts took place. *But when these parts, which were all present, were subjected to painful excitations by water heated gradually to boiling, the frog did not make movements of escape; its reflexes did not combine.* The same conclusion is borne out in the behavior of Bechterew's decerebrate bird when it alighted on a hot perch. It would lift first one foot and then the other, but would not save itself by flying away. The reflex movements of both legs failed to combine.

Earlier in the chapter it was noted how one of Lashley's rats showed a persistence of the maze-habit after the motor areas and caudate nuclei had been destroyed, but, in the performance, *there suddenly developed an entirely new set of movements never before employed in the maze situation.* When the rat found it impossible to make a left turn she rotated 270 degrees in order to reach the goal. *If this performance were a sudden combining of reflexes one would have to assume an infinite number mysteriously ready to function in an infinite variety of novel situations. The conditions are satisfied, however, for an execution of the movements under the laws of dynamics. The animal possessed a goal. Stresses in the nervous system had*

been aligned with respect to this goal. The whole conditioned the activities of its parts, and, without practice in the new situation of being unable to make a left turn, she made rotating movements with reference to the goal. This she accomplished for the same reason that when a stream of water is dammed up it takes the shortest route around the obstruction.

The All-or-None Law. Recent investigations by Forbes and Adrian [4] bring out a most important principle relative to single neurons and the synapses between them. Whenever a neuron responds, it responds at a maximum throughout. For example, when fibers along a section of a nerve are partially

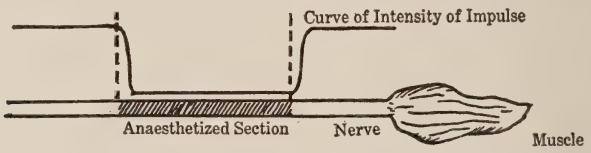

FIG. 12. SCHEMATIC REPRESENTATION OF THE ALL-OR-NONE LAW, AS IT APPLIES TO NERVE CONDUCTION. After Forbes and Adrian.

anaesthetized, a current passing through the anaesthetized region is found to be less than the current behind the affected part. But by the time the impulse reaches a very short distance beyond the anaesthetized region it exhibits normal strength again, thus indicating that the loss has been regained. (Fig. 12.) All this would indicate that if neural activity were cut down by resistance at the synapse *it would become maximum again before it reaches the next synapse. Resistance at the synapse, therefore, cannot be a factor in the organization of nerve impulses.* Instead, gradients of potentiality control the direction of nerve impulses, and there is no gradation at the synapse.

The Dynamics of the Cortex: Bartley, Newman, and Perkins. Bartley and Newman,[5] and subsequently Bartley and Perkins,[6] investigated the dynamics of the cerebral cortex

[4] Forbes, A., and Adrian, E. D., "The All-or-Nothing Response of Sensory Nerve Fibers." *J. Physiol.*, 1922, Vol. 56, 301-330.

[5] Bartley, S. H., and Newman, E. B., "Recording Cerebral Action Currents." *Science*, 1930, Vol. 71, 587.

[6] Bartley, S. H., *Gross Differential Activity in the Dog's Cortex.* 1931, University of Kansas. Dissertation.

Perkins, F. T., *A Study of Cerebral Action Currents Under Sound Stimulation.* 1931, University of Kansas. Dissertation.

in dogs. They employed vacuum 'radio' tubes, together with the proper accessories, capable of picking up and amplifying the electrical aspects of brain currents (action currents). The amplification varied from 50,000 to about 400,000 times the intensity of the original nerve currents. Thus the currents were made sufficiently strong to affect the balance of a delicate wire string poised in a magnetic field. A light beam, reflected from a mirror on the wire string, was trained upon a moving picture film. In this way the vibrations characteristic of the action currents of the brain could be photographed. By placing electrodes on different parts of the cortex while the dog was carrying out different activities under light, sound and touch stimulation, it was possible to determine the extent of activity taking place in any given region. Provided the dog itself was active, *there were high concentrations of energy in the visual area whether the dog was being stimulated with bright light or not, and in the auditory area whether or not the dog was stimulated with sounds.* The visual area has something to do with vision, certainly, and the auditory area has something to do with hearing, but in any case, there was no evidence of localization of function. On the contrary, the brain as a whole was active in all performances of the dog. The field of energy always showed definite gradients extending across the cortex from its anterior to its posterior end, and these gradients took on different patterns in the case of different modes of behavior (Fig. 13.)

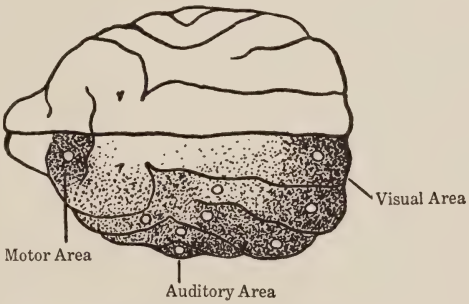

Fig. 13. Dynamic Map of Dog's Cortex.

Action currents were recorded while the dog was responding vigorously to pain stimulation. Shading represents degree of cortical activity. There was no auditory stimulation; visual stimulation was merely the light of a dimly illuminated room. The light circles show positions of the electrodes. After Bartley.

Theory of the Nervous System

A Theory of Brain Functioning. First, the brain as a whole functions in the execution of any given performance. It is a fluid, dynamic field of potentials balancing themselves at any given moment against disequilibration induced by stimulation from the sense organs. It is a system akin to a gravitational system, having a field property in the form of a balance or gradient of stresses. The field is a unit, a whole over and above the sum of its parts; thus the functioning of the brain illustrates the law of field properties.

In the beginning, the brain-as-a-whole exhibits equipotentiality (Lashley), that is, the duty that any one part will eventually perform is not determined by factors inherent in that part, such as a peculiar structure, or a position in the field determined by inheritance. The structure and position of a given part are determined by the dynamic field into which the part grows. Thus the visual area is important for vision not because it was made, anatomically, to be the seat of vision, but because it happens to be the threshold into the cortex from the eyes, and therefore the line of least action for the bulk of energy activated by retinal stimulation. If the same tissue were the threshold from the ears into the cortex, it would have a corresponding importance for hearing. The original field, dynamically capable of being differentiated in any direction, is differentiated into gradients solely in accordance with the laws of dynamics.

Second, the brain functions in accordance with the laws of derived properties and determined action. Each part is like a soldier in an army. Its duty depends upon the purpose or function of the whole. It seems evident, for example, that the visual area has some part to play in the total economy of the brain even when the organism is not responding to visual stimuli, for action currents, corresponding to movements made in consequence of other stimuli, may be taken off the visual area. At other times the visual area is most certainly functioning in an important way, while the animal is responding to visual stimuli. The same principles are clearly demonstrated within restricted regions of the motor area. At one time direct electrical stimulation of a given part will induce an arm movement of the

animal; at another time a head movement. The function of a given part depends upon what the whole is doing.

Third, since all of the organismic laws imply each other, and since the laws of individuation and field genesis were illustrated in the embryonic development of the nervous system, it seems beyond doubt that refined methods will eventually demonstrate these laws in the functioning of the adult cortex. Indeed, as will become obvious in a subsequent chapter, these laws are clearly exemplified through observations of behavior in adult learning. The neural and behavior-patterns can be no other than aspects of each other, and both are expressions of a growth potential. The laws of nerve conduction are the laws of dynamics; and any changes occurring in the manner and extent of nerve conduction can be understood only in terms of these laws.

Fourth, at any given time a certain set of stimuli produces neural tensions that constitute the high potential regions of the brain. But these regions do not take on a high potential, and do not discharge their energy, until low potential areas are established. These low areas are established by the same stimulus-pattern, or total situation, that produced the high potential areas. Thus nerve action is an organized response to a total situation that furnishes the beginning, the direction and the end of a nerve current. The brain functions, therefore, in accordance with the laws of least action and configuration.

The Physiological Basis of Mental Development. We are now ready to summarize the facts and principles pertaining to the nervous system and to apply them to the problem of mental development. At any stage in its development, the nervous system is ready to function, with respect to a given set of stimulus-conditions, *before* it is stimulated. Nerve cells develop and multiply in an organized way, as an expanding and differentiating dynamic field, and according to a definite pattern which follows its own laws of growth. These laws are, again, the laws of dynamics. The pattern is established, then, before excitation, 'exercise' or 'experience' begins. It forms in the course of growth or maturation. The laws of mental development are laws of maturation, not laws of experience, or exercise, as these terms are customarily understood.

Maturation is the expression of a growth potential. It is a form of stress resolving itself toward a remote end. The end is the last stage of maturity, and the resolution assumes the form of growth. Psychologically this growth is called mental development. Special cases of it are the development of personality, development of intelligence, the learning of all manner of tasks such as language, playing musical instruments, golf, and school subjects of all kinds. The acquisition of experience is, itself, the psychological way of looking at maturation; it *is* learning. The organism *does not* develop and learn *by* experience, but *with* it, *under a growth potential.* Every new experience or increment of progress in a learning process arises through emergence or individuation from a mass activity of some sort. The emergence is induced, within limits, by stimulation.

Introduction to the Problem of Maturation: Köhler's View. Maturation is a differentiation of energy patterns, or systems of stresses in the nervous system, which are organized as they differentiate. A change, effected in the nervous system by an external stimulus, demands a mutual adjustment between itself and pre-existing systems of stresses. As a result of this adjustment, new modes of behavior and new experiences are made possible, provided stimulations occur fast enough to keep the stress-patterns within the nervous system increasing in their complexity. This condition would be satisfied if changes in stimulation came often enough to prevent a return of the patterns concerned to a state of equilibrium, for then new changes must continually balance themselves against old changes that are still going on. There is, therefore, not only an adjustment to an external stimulus, but an adjustment of one internal change to a previous, unfinished change, induced by a previous stimulus. There is a preservation of balance while the balance itself is changing. Stated in different terms, stimulation produces a change in stress-patterns against which there must be a rebound, but, since the rebounds are never completed, the total situation in the nervous system is constantly becoming more complicated. In this way the rebounds result in a more highly differentiated condition of the nervous system, and this means more highly complicated thought and action.

Function of the Stimulus-Pattern. The function of the stimulus-pattern that induces maturation may now be inspected more closely. Imagine a ball of soft 'elastic' substance. Various degrees of pressure are applied to this ball in different places on its circumference. The ball will then modify its shape to meet these different pressures. There have been created within the ball regions of stresses of varying amounts. The instant the 'pressure-pattern' is released the stresses are eliminated and the ball resumes its spherical shape.

Stimuli are akin to pressures, acting upon the nervous system, and the nervous system is akin to the ball. The regions of stresses in the nervous system are concentrations of energy existing under varying potentials. These concentrations will vary as the 'pressure-pattern' or stimulus-pattern varies. If the pressure were applied several times in rapid succession, each time differently than before, the stresses in the ball would become more complex. They would differentiate in the manner described in the preceding section.

Precisely what is a stimulus-pattern? It consists of many forces: light rays, sound waves, mechanical contacts against the skin, tensions in the muscles of the body, all of which 'press,' that is, impinge, upon the sense organs of the body. These forces reach the organism arranged in all sorts of ways and with varying degrees of intensity. A square reflects in a certain way light rays from its boundaries to the retina, but a circle reflects an entirely different pattern of rays. Sounds impinge upon the ear with a wide range of intensity and pitch, each sound having a different pattern of vibrations. Each movement of the body stimulates the nervous system through the medium of sense organs that lie in the muscles. According to the rate, extent and vigor of the movement the pattern of stimulation is different. Look out over a landscape. Reflected rays from objects far away and near and of varying brightness and color all constitute a complex stimulus-pattern. Space, time, intensity relationships of stimuli, and the character of the forces themselves furnish a complexity of pattern that could only be adequately conceived after a detailed study of the sense organs of the body and the precise nature of the forces that act upon them. These are the forces corresponding to the

pressures which were applied to the ball. They are the stimuli that, when repeated, induce maturation, and maturation involves differentiation.

Maturation from an Anatomical Standpoint. As the differentiation continues the energy concentrates in relatively stable patterns, so stable that they may be called structures. These structurizations are, it may be supposed, none other than growth of dendrites, and perhaps axon collaterals. Coghill's study of the salamander showed that a growth of axon and dendrite terminals *over a distance of less than one hundredth of a millimeter changed the organism from a helpless, passive condition to an active, exploring creature!* It is known, further, that there is ample room in the brain for considerable structural development after the organism has reached the maximum of its height and weight. Indeed, it is probable that the nervous system grows, throughout life, in the same fashion as in the embryo, but perhaps more and more slowly as old age approaches.

It is not known to what extent energy patterns in the brain may differentiate without visible structural changes in the form of complications in the nerve cell. Whether this extent is slight or great, it must be remembered that any differentiation of energy implies some kind of structurization, whether visible or not.

Significance of the Foregoing Facts for Mental Development and Education. The facts of this and the preceding chapters give us a foundation for an understanding of the learning process and mental development in general. *The conclusion is inevitable that the acquisition of experience and the acquisition of muscular co-ordination are functions of maturation and stimulation.* This principle is of profound importance for education. It means, first, that what the child primarily demands is a chance to develop. It means, second, that *learning is a continuous process of making discoveries, doing something that never has been done before.* It is growth in a specific situation, *anything but repetition of a performance.* Third, *the first responses of the embryo are general and undifferentiated. The first responses made by a child and even an adult in any new situation will exhibit the same characteristics.*

They will be mass actions, and from these mass actions the organized and specialized responses will emerge through individuation. This means that learning is always accomplished by the whole method. Fourth, the fact that development and learning occur with, not by means of, exercise and experience shows that *repetition of response does not account for learning.* Executing a performance 'imperfectly' is a sign that maturation is incomplete, perhaps that the task is beyond the level of the learner's stage of maturation, and should be postponed. Awkward and apparently random performances in different situations (so-called trial and error procedures) are not movements from which successful trials are to be selected and unsuccessful ones eliminated. Fifth, the principle that the whole controls its parts demands, in terms of least action, an *emphasis upon the child's initiative and will to learn.* It demands, further, that all learning processes be studied as differentiations of personality. The whole comes first, and personality is the psychological whole. *Whatever the child learns is accomplished in the course of developing a personality and of maintaining the integrity of that personality.* Education deals with human wholes that grow through organized differentiation. Education must guide that differentiation, first by ascertaining what the organization is, then by stimulating it in the appropriate directions. Education is not a process of providing so much learning here, so much there, and of putting the bits together. It is the promotion of a unified, interrelated body of knowledge.

There are, in fact, so many new emphases required in the educative process, as a consequence of recent developments in physiology and psychology, that they cannot all be enumerated here. The remainder of the text is devoted to the task of enlarging upon the facts and principles thus far brought to light.

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CHAPTER V

EVOLUTION OF THE LEARNING PROCESS

The Antecedents and Origin of Intelligent Behavior

Introduction. In the past, the ordinary layman has felt that comparing the behavior of animals and man was pointless, and degrading to man's position in the universe. Nothing could be farther from the truth. First, the preceding chapters have illustrated that, throughout the animal scale from the lower animals to man, the same laws apply not only to the growth of the nervous system, but to all other organs as well. These same laws are applicable, generally, in the so-called physical world. Likewise, in a study of the learning process, the same laws that apply to the human organism apply to animals with a consistency just as striking. It is not meant that infra-human animals and the human subject are alike in all respects any more than the nervous system is, strictly speaking, a gravitational system. Rather, it is meant that the same laws apply to animal and human solutions of problems, although the problems differ widely in their complexity.

Second, if then it is possible to set up problems for the adult animal, these same laws can be observed more conveniently and concretely in simple problem-situations than in the more complex situations which would be appropriate for adult human subjects. Third, man undoubtedly passes through periods in his early development that are similar to the infra-human stages, but in the human subject early development is such a rapid process that only a few of its phases can be studied in detail. If, however, the behavior of the animal is investigated intensively, a detailed picture of the development process can be obtained. Fourth, experimentation on the learning process in animals also offers a greater variety of controls obtained by changing at will the conditions under which the learning occurs.

Fifth, in the animal we have an organism sufficiently simple to permit, easily, the relative isolation of a given learning process for the purpose of specialized study. Sixth, animals are always available and the same conditions can readily be duplicated when it becomes necessary to verify the facts of observation. Seventh, artificial injuries to the nervous system of the animal may be introduced experimentally, and the consequences observed, as shown in the foregoing chapters. With these advantages in mind we may proceed to a genetic study of the learning process in the animal scale.

Invertebrate Behavior. The task of examining in detail the evolution of the learning process at once raises the question, Where does learning begin? In order to answer this query it will be necessary to examine how the simplest of the animals behave, such as the earthworm. If a particle of food is placed near by, stimuli that originate in the food act upon one side of the worm's body and cause the muscles on that side to contract more than those on the other side. As a result the worm turns toward the food until both sides of the body receive equal stimulation.

'Tropisms' as Organismic Phenomena. The behavior that has just been described was called a *tropism* by Loeb,[1] a term that soon came to be applied very generally to the behavior of invertebrates. Responses of these animals to light were called phototropisms. The term geotropism was used to denote responses to gravity, rheotropism to describe responses to currents and galvanotropism to describe responses to electrical fields. Loeb explained these tropisms in terms of specific irritability (sensitivity to stimuli) at the surface of the animal, and in terms of body symmetry. Noncorresponding elements on opposite halves of the body show unequal irritability; corresponding elements possess the same irritability; and the anterior part of the organism is more sensitive than the posterior part.

In all this behavior the organism *is an active participant* in the stimulus-situation. The earthworm was not 'drawn' to the food, but the unequal stimulation on its body, set up by the

[1] Loeb, J., *The Mechanistic Conception of Life.* University of Chicago Press, 1912.

total food-situation, produced an unequal tension, *which the animal itself balanced by making certain movements.* 'Tropisms' may, then, be defined to mean an *organized response* to a total pattern of stimuli. This response is made in the line of least action toward equilibrium, that is, until the forces within the animal are balanced with respect to each other and with the forces outside. A total system of forces of which the organism is a member is giving direction to this activity. The organism modifies its own behavior in the light of the stimulus-pattern and the modification occurs in resolving a tension toward a goal. Thus, when the earthworm turns toward the food its behavior is directional. This is precisely what happens, *in principle,* in intelligent behavior. An animal or human being is directing his activities toward a remote end, which may be food or the solution of a puzzle. The goal is the point where the tension is resolved. The antecedents of intelligent behavior are therefore to be found, in the light of this view, in the behavior of the earthworm. Indeed, they are to be found in still simpler forms of behavior, such as in the ameba, for this animal, also, *modifies its own behavior* in resolving tensions toward remote ends.

Modifiability of Behavior in the Ameba: Schaeffer. The ameba is a one-celled animal having no permanent shape or appendages. It swims by means of a general flowing of its protoplasm from one part of the animal to another, and secures its food by enveloping particles of edible material with a pseudopod or streamer of protoplasm, thus forming a food-cup around the particle. Schaeffer,[2] experimenting on food responses in these animals, found that if non-edible material, like glass or carbon, was made to vibrate in their path, they would injest it. He placed a piece of glass in front of a hungry ameba and made the glass vibrate by means of a rod. The animal immediately injested it, but, six minutes later, expelled it. After an interval of five minutes the same piece of glass was presented as before, and again the ameba injested it. This time the animal expelled the glass at the end of three and one-half minutes. In each of these two trials a complete food-cup had

[2] Schaeffer, A. A., "Choice of Food in Ameba." *J. Anim. Beh.,* 1917, Vol. 7, 220-252.

formed around the glass. In the next trial, however, the cup was only three-fourths completed before the material was expelled. Two further presentations of the glass induced noticeable food responses without complete formation of the cup. After this the ameba became indifferent to the glass. Throughout, it is evident that the animal was making a definite contribution to its performance, for it changed its behavior in meeting a novel situation. The continued presentation of nonedible material in the animal's path set up a tension the resolution of which came about through a *modified form of behavior, an indifference to the vibrating stimulus.*

It may be concluded, on the basis of these results, that the beginnings of the learning process involve, first, a contribution to the situation on the part of the animal. Second, there is a response of the animal toward a goal. In terms of dynamics the goal is reached in the resolution of tension set up by a new stimulus-situation. Third, the animal modified its behavior to meet this new situation.

Experimental Studies of the Lower Vertebrates

Perkins and Wheeler on Goldfish. The antecedents of an intelligent response have been shown to exist in the one-celled animal. Among the lower vertebrates, the fish illustrates a typical phase in the evolution of the learning process. Perkins and Wheeler,[3] following the general method of Köhler, Révész, Helson, and others, experimented on goldfish in order to determine if animals of this relatively low order could respond to one stimulus in its relationship to others in a total situation. The apparatus consisted of three lighted compartments, containing food, and arranged in a semicircle. (See Fig. 14.) The fish (42 in all) were placed at X in the choice-compartment in front of the lighted doorways. One group of animals was trained to respond to three absolute intensities, some to the brightest, some to the middle, and some to the dimmest. After the animals responded correctly to a given light, changed in position after each trial, the lights were all shifted or

[3] Perkins, F. T., and Wheeler, R. H., "Configurational Learning in the Goldfish." *Comp. Psy. Mon.*, 1930, Vol. 7, 1-50.

'stepped down' in intensity, without destroying the relationship of bright, medium and dim. The correct response for the fish that had gone to the dim light was now the wrong response. In spite of this fact the fish made correct choices in nearly every instance. When all the lights were 'stepped up' in brightness, so that the stimulus, now the dimmest, was as intense as the brightest light in the original combination, *the fish continued to make correct responses.*

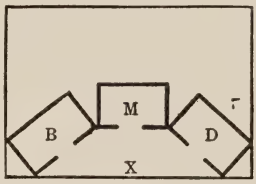

FIG. 14. APPARATUS FOR GOLD-FISH EXPERIMENT.

X indicates the starting place. B, M and D represent bright, medium and dim compartments, respectively.

These investigators trained another group of fish to choose the dimmest or middle or brightest light in any combination of three lights, when *the absolute intensities* as well as the positions of the lights *were changed after each response* of the animal. Moreover, the differences in brightness were not the same from one response to the next. The fish learned this problem as readily as they had learned the one in which the absolute intensity of the lights remained the same. At the end of the experiment a test was given in which the fish responded correctly to various novel patterns of intensity, position, and brightness relationships.

The Concept of Insight: Criteria. In order to describe the type of goal-activity exhibited in the goldfish experiment and the experiments that are to follow, it is necessary to select a new term, descriptive of an organized response at the level of conscious behavior. This term is *insight.*

An organized response, as should now be evident, exhibits certain definite characteristics. It is directed toward a remote end, that is, complex movements are organized with respect to an end. Moreover, when a new stimulus-pattern presents itself the movements are still directed toward a remote end but the organization is a *new* one. Frequently this new response resolves the tension; the goal is successfully reached; the response is correct the first time, depending, of course, upon how much the situation has been changed. Thus it can be seen that each new response possesses a property of uniqueness. Insight describes this uniqueness. In everyday language it means, in

human behavior, a *grasp* or *understanding* of a *new* situation without experience in that situation.

There are various criteria by means of which insight can be recognized. The first of these is the *modifiability* of behavior, resulting in correct responses to new situations the first time. The problem-situation presented to the animal set up certain tensions, which its usual mode of response failed to resolve. As a consequence the animal changed or modified its behavior to meet that situation. *This modification was illustrated in the goldfish by sudden spurts of learning.*

The second criterion of insight is *transposability of the general properties of response from one problem to another.* This was also demonstrated by the goldfish. Animals, trained to choose the brightest of three absolute light intensities, for example, were hardly influenced when the lights were all stepped up or down. In fact many of the fish made 100 per cent correct choices immediately after the transposition was introduced, indicating that they were responding in an 'intelligent' manner to the new situation. The fish on which all the brightness values were shifted after each response, were forced to solve a new problem each time; they were transposing after each response, and yet they learned the problem. The tests presented these animals at the end of the experiment involved additional new situations, not only with respect to absolute brightness values, but with respect to relationships between the lights; and yet the animals responded correctly. They were not making stereotyped responses, but had perceived what a human being would call a principle. They perceived in their own way a constant set of relations running through the several stimulus-situations.

The third criterion of insight is the configurational character of response, *the response to a total pattern of stimuli.* The goldfish did not react to an isolated light, *but to that light in its relation to the other two.* The animals, trained to the dim light, for example, could not have responded to that light, as such, or they would never have been able to choose correctly in the transposition experiments. The property of 'dimmer than the other two,' or in other words, the *relative* brightness of the light, made the stimulus significant for the fish. Such a

property has significance only in relation to a total pattern of stimuli.

The animals showed, in other ways, that they were not responding to an isolated light, but to that light in its relationship to the total pattern. They would characteristically swim around in front of the illuminated doorways, evidently 'looking over' the situation before making a response. In the group of animals that responded to the constantly changing pattern of lights the responses were all the more obviously configurational, that is, there was no constant or absolute stimulus present. The only relevant feature of the stimulus-pattern was a relationship of bright, dim and medium, which can only be a property of a total situation. The light to which the fish responded as the means of reaching the food goal possessed its property of 'correctness' only as it was seen in relation to the stimulus-pattern of which it was a member.

Dual Use of the Term Insight. The term *insight* can be used in two ways, which, for the sake of clarity, should be explained here. The first use of the term involves the animal as the point of reference. In this case, the animal is assumed to have its own insight into every situation that it confronts, although the response it makes may be an error from the point of view of the experimenter. The animal always responds to a goal of some kind in an effort to relieve the tension set up by stimulation. It must perceive this goal, or remote end, before it can respond, and it must perceive the path to the goal in relation to the goal itself. Thus, the goldfish makes a response to the light situation as it sees it, but makes an error. To say that it lacked insight is to impose a human standard upon its behavior. *The imposed human standard is irrelevant to what the fish was doing, and may be called the fallacy of the double standard. Any effort to describe an animal's performance in terms of trial and error commits this fallacy.*

For the second use of the term insight we may assume the problem as the point of reference. In this case the animal has insight into the problem assigned it when it solves that problem. Thus, we say that he lacks insight at the beginning of the learning process. This does not mean, however, that the animal is reacting blindly or by trial and error in this early stage, but in

just as insightful a manner, with respect to conditions relevant to its behavior, as in a later stage. It is the second connotation of the term that will be used in discussing further studies in the evolutionary development of the learning process.

Experiments on the Chick: Bingham, and Révész. Bingham[4] trained chicks to choose the larger of two circles. He then transposed the animals to circles which were much smaller, but which still possessed the same size relations. Animals that had been trained to choose a 6-centimeter circle and to reject a 4-centimeter one, would choose the latter when it was presented with a 3-centimeter circle. This experiment indicated that the animals were not perceiving size, as such, but a relationship between sizes.

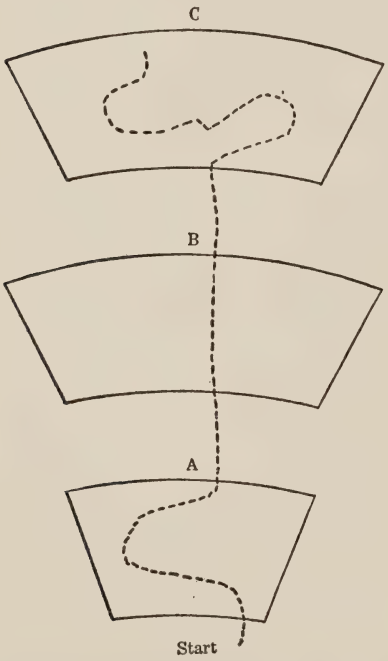

Fig. 15. The Jastrow Illusion as Used in Chick Experiment. After Révész.

Révész,[5] also working with the hen, trained his animals to choose only the smaller of two circles, each covered with grains of wheat. When this problem was learned the hens were given pairs of squares, parallelograms and triangles that differed in size. Without any further training they chose the smaller figure of each pair. The animals were then given segments of circles, varying in size, with the intent, later, of presenting them with segments in the form of the Jastrow Illusion. (See Fig. 15CB. The upper segment appears to be smaller subjectively, but actually the two segments are the same size.) For further introductory training the animals were presented

[4] Bingham, H. C., "Size and Form Perception in *Gallus Domesticus*." *J. Anim. Beh.*, 1913, Vol. 3, 65-113.

[5] Révész, G., "Experiments on Animal Space Perception." *Brit. J. Psy.* (Gen. Sect.), 1924, Vol. 14, Pt. 4, 386-414.

segments of circles in various awkward positions, with the result that they still chose the smaller. Then they were given the Jastrow figures. *Without delay they walked across the subjectively larger segment and chose the subjectively smaller one beyond.* In a final test three segments were presented, two larger of the same size, and one smaller. The actually smaller one was nearest the hen and the subjectively smaller of the larger two was farthest away. The hens cleaned the food from the actually smaller segment, then, still hungry, passed over the subjectively larger of the other two segments, and took food from the subjectively smaller one.

These experiments demonstrate, even more clearly, responses that involve the perceiving of relationships, or what would be called a principle in the case of human behavior. The animals could not have been responding mechanically to separate and discrete stimuli, for, had this been true, they would have continued to go to the stimulus originally learned as the one from which to secure their food. Instead, they disregarded the absolute value of the stimulus, in this case, size, and chose on the basis of relative values. When one stimulus is chosen in its relation to another it means that, for the responding animal, the stimulus-values are mutually dependent; each has a property only in relation to the other. In turn, this means that the organism must respond to the total situation or not at all. In this and the preceding experiments, therefore, the animals were making *one* response in the form of an organized *unit.* This one response exhibits *a field property, the perception of relative brightness, size, or form, as the case may be.* In simpler language, the animal exhibits insight; it is making a *configurational response.*

M. Cutsforth's Experiment on Chicks. M. Cutsforth [6] trained large numbers of chicks to follow a certain plan in solving a complicated light discrimination problem. In order to secure its food the chick was obliged to choose the dimmest of three lighted doorways in a first bank of doors, the medium lighted doorway in a second bank, and the brightest doorway in a third bank. (Fig. 16.) All of the criteria of insight men-

[6] Cutsforth, Marjorie G., *A Study of Successive Discrimination of Brightness in Chicks.* 1930, University of Kansas. Dissertation.

tioned in connection with the goldfish, and other experiments on chicks, were verified.

In another experiment, prescribed choices were imposed upon the chicks in case of the first two banks, while the third bank of doors was left open, with no light cues. When the problem had been learned the third bank of doors was illuminated in order to ascertain if the chicks, having chosen the dimmest light in the first bank and the medium light in the second, would continue up the scale of intensity, and, of their own accord, choose the brightest light of the third bank. As far as this purpose of the experiment was concerned, results were negative; but *the chicks, without a single exception, adopted some plan of their own in choosing the door through which to pass. There was no evidence of random or trial and error activity.* The positions of the lights in the bank were changed after each run. One chick disregarded the brightness of the stimuli entirely, and consistently went to the left-hand doorway. Several chose the middle doorway, regardless of its illumination. One of them began choosing the brightest, and another the dimmest, and carried out this method consistently, following the light as its position was changed. These results are consistent with the main thesis of this text that behavior, under no circumstances, is actually random or carried out in a trial and error fashion; and prove that when the animal is not trying to learn the problem prescribed by the experimenter, it is setting up goals of its own.

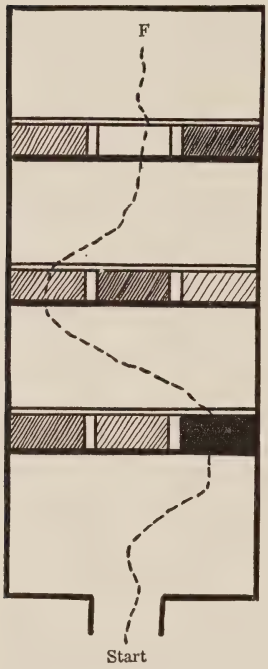

FIG. 16. VIEW OF M. CUTSFORTH'S CHICK APPARATUS.

Looking down from above. Shading indicates the relative brightness of each light in the three successive banks. F, food. Dashed line, correct path.

Experimental Studies of the Higher Vertebrates

Configurational Behavior of the Rat: Higginson's Experiment. In ascending the evolutionary scale, the white rat offers the next convenient stopping place. Higginson [7] used a standard circular maze, modified to the extent that the doorway leading from the outer pathway to the inner (from 2 to 3 in Fig. 17) was fixed with a tightly fitting door. This door was closed when the rat was placed in the maze. Before the experimenter would permit the animal passage through the door, it had to proceed the length of the *cul-de-sac,* turn around, and start back toward the entrance of the maze. When now the animal reached the doorway, it was open, and the way was clear to the end of the maze. Thus, the rat was obliged to traverse the full length of the *cul-de-sac,* six feet, each time it ran the maze. Each time, when it came back and entered the doorway, it *turned to the left.* At the end of 100 trials (the animals required 25 trials to learn the problem) the door to pathway 3 was left open at the outset. Five out

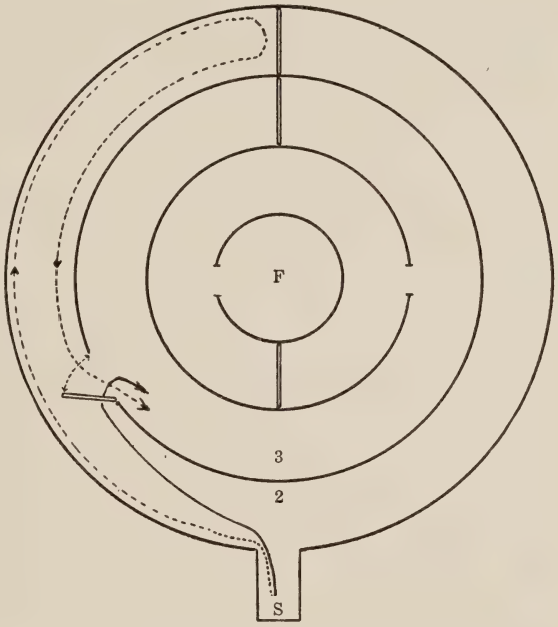

Fig. 17. Circular Maze of Type Used in Higginson's Experiment.

Dashed line shows path before door was open as rat entered maze. Solid line shows path after door was opened. S, start. F, food. By permission.

[7] Higginson, G. D., "Visual Discrimination in the White Rat." *J. Exp. Psy.,* 1926, Vol. 9, 337-347.

of the nine rats, without running the extra six feet to the end of the *cul-de-sac* as they had done 100 times previously, *immediately took the open door.* The other four animals changed their path after making only one or two errors. All the animals then approached the open doorway, stopped suddenly, entered it by *turning to the right* and ran the rest of the maze perfectly.

These animals had been responding, during the first phases of the experiment, to a stimulus-pattern which offered them a problem. Only by solving the problem could the goal be reached. But more than this, the animals had learned a certain pathway to the goal, the shortest under the existing conditions, and when the closed door was eliminated they met with a new problem. A different route was now the shortest. What was the rat's response? It transposed perfectly from the one situation to the other. There were no identical responses to be carried over, or any responses that could have been fixed by repetition. It had previously traversed the long path the most frequently and the most recently. In addition, *it had never entered the doorway from the right before.*

Helson's Experiment. Helson,[8] also working with the white rat, performed an experiment in which he found that these animals very rapidly learn to choose the brighter of two lights. After they had mastered this problem, he presented them with a stimulus-pattern in which the absolute intensities of the lights were changed, but the relationship of bright and dim remained the same. Still, the animals responded correctly. In another experiment he surmounted two adjacent food-compartments with greys of different brightness. In front of each of the compartments he placed an electric grill, for use in shocking the animal when it chose the path to the wrong compartment, that is, the wrong grey. After having been shocked a few times the animals showed fear even of the dead grill.

In two of the rats interesting behavior was exhibited early in the experiment. One of them had just made a wrong choice and had been shocked as it went over the grill in front of the compartment, when, instead of backing across the grill in order

[8] Helson, H., "Insight in the White Rat." *J. Exp. Psy.*, 1927, Vol. 10, 378-396.

to reach the starting place again, as it had done nine times before, it now climbed over the partition, separating the two compartments, to the food on the other side. Another of his rats did essentially the same thing. Both animals had taken the shortest possible path in their approach to a goal. (See Fig. 18.)

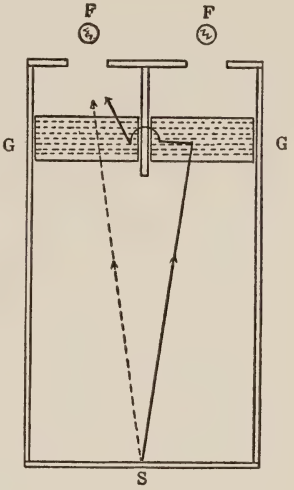

FIG. 18. DIAGRAM OF HELSON'S APPARATUS, USED IN RAT EXPERIMENT.

Solid line shows path of rat in avoiding the grill (G). By permission.

Directional Character of the Rat's Behavior. In order adequately to understand this type of behavior remember that its primary feature is a perception of the goal in its relation to the entire stimulus-pattern. This has already been demonstrated by the fact that a change of the absolute properties of the goal, or any part of the stimulus-pattern, without changing the relationships between the stimuli, does not affect the animal's performance. Recall, also, that tension has been set up in the animal; it is hungry, and the goal that resolves the tension is food. But it is not food in the abstract; it is food in a certain compartment. Helson's animals reached this goal by perceiving a certain light, or a certain grey in relation to the food. Reflect upon what this means! *The animal must perceive the goal before activity can commence, which, of course, means that all activity is executed with respect to something and is not random, even at the beginning of the performance.* From Coghill's work it was discovered why an animal *cannot* make a random response. The nervous system will not permit it.

The problem remains of explaining how particular tensions and goals are set up. They are set up by stimulus-patterns which form the energy of the brain into gradients, or alignments of potentials, with a complicated outlet of nerve energy, down the gradient, toward a condition of equilibrium. This complicated outlet of nerve energy is just that pattern of dis-

charge that enters the muscles and terminates in complex movements toward the goal. What we have been calling insight is the psychological aspect of the original alignment process. The flow of discharge into the muscles is over lines of least action; the movements of the animal occur over the shortest routes in time toward the goal; the animal perceives the shortest route, possible, toward the goal, in the light of its orientation to the particular problem-situation. These are all ways of telling the same story. Helson's rats that climbed over the partition strikingly illustrate this principle. They perceived the apparatus from a new angle; in the course of running the simple maze they learned it as a whole and discovered, through insight, a shorter route. The same stimulus-pattern to which they responded insightfully was the one with respect to which the brain potentials were aligned that led to the directed movements. The experimental goal was discovered, therefore, under the law of least action.

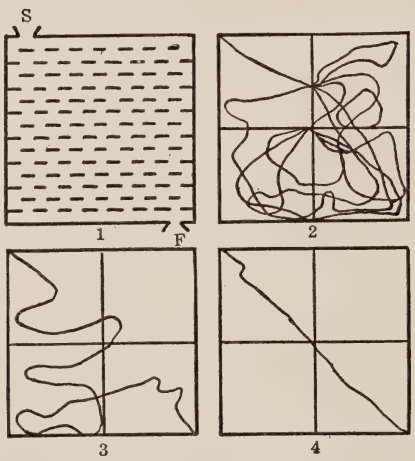

Fig. 19. Schematic Diagram of Maze Used by Gengerelli.

(1) Diagram of maze. (2) Typical path traversed in first part of experiment. (3) Path at a later stage in the learning process. (4) Path when problem had been solved. Modified after Gengerelli, *J. Comp. Psy.*, 1930. By permission.

Least Action in the Behavior of Rats: Gengerelli. Gengerelli [9] has subjected the theory of least action to a systematic test in an experiment on the white rat. He constructed a checkerboard maze of the plan depicted in Fig. 19 with the entrance at one corner and the food at the opposite corner. At first the rats did not know the position of the food box. This meant an exploration of the maze. The maze was so constructed that there were many alternate routes to the food-goal,

[9] Gengerelli, J. A., "The Principle of Maxima and Minima in Animal Learning." *J. Comp. Psy.*, 1930, Vol. 11, 193-236.

some longer and some shorter. As soon as the rats became familiar with the maze-pattern as a whole they selected the most direct route from the starting place to the goal. Frequently the improvement was sudden, the rat rapidly cutting down the distance travelled to the goal. Gengerelli's results show that *what the most direct route in time shall be depends upon a dynamic relation between the animal and the total maze situation.* This dynamic relation is not set up until the animal has become oriented to the maze as a total situation. This fact harmonizes, of course, with the conditions for least action anywhere, for a moving body, in order to follow the most direct route in time toward a remote end, *must be in dynamic relation to an entire field.* This dynamic relation, in case of conscious organisms, is represented in consciousness by a perception of the total situation in which each part is apprehended in relation to the whole.

Adams' Experiment on Cats. In passing from the rat to animals higher in the evolutionary scale, the cat offers convenient material with which to study the expansion or complication of the learning process. Adams,[10] following the general method of Thorndike, used these animals as subjects in a series of puzzle-box experiments. The cats were placed in a box with spring-hinged doors, fastened with an ordinary barrel-bolt. When the cat pulled the bolt, the door opened and the animal escaped to the food. Other boxes were also used, one in which a rope was attached to a catch-door. From this door the rope led over the top of the box, by way of a pulley, down to the opposite side within reach of the animal. Thus, in order to escape through the door at the front, the animal must pull the cord at the back of the box. (Fig. 20.)

In other experiments Adams presented his animals with strings tied to pieces of food. The end of the string lay inside the cage, and the food lay outside either below the cage or some distance away on a surface horizontal to it. In the case of the horizontal string-pulling experiments the string was arranged in an angular fashion on the floor, so that the food was never directly in front of the cat. When the cats were placed in the

[10] Adams, D. K., "Experimental Studies of Adaptive Behavior in Cats." *Comp. Psy. Mon.*, 1929, Vol. 6, 1-162.

experimental situation for the first time they would, perhaps, explore the box, make a few efforts to escape in the direction of the food, then sit down. The most characteristic feature about the initial behavior of the animal was lack of activity of any kind, rather than any so-called trial and error efforts. As the experiments progressed the animals became more active,

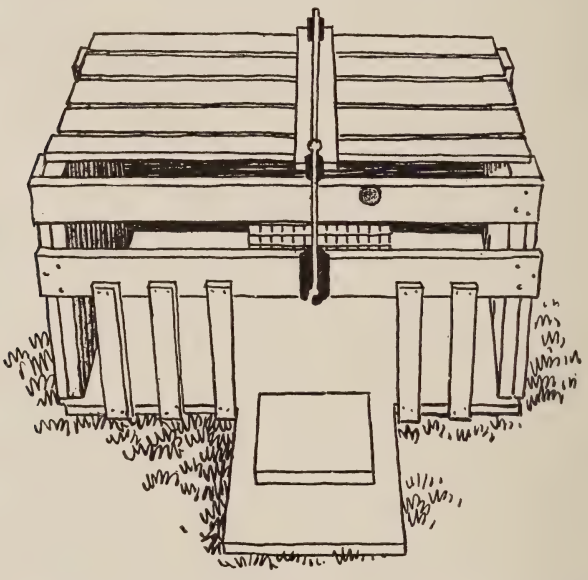

Fig. 20. Puzzle Box of Type Used by Adams in Experiment on Cats.

concentrating their activity, however, on efforts to escape. When the cats once discovered the latch or the principle of the string-pulling, *from that time on all activity was directed toward the relevant parts of the box.*

On the ninth day of experimentation, one of the animals, Fritz, exhibited curious behavior in a box with a button-latch. He went to work on the button immediately, moved the long end through about 45 degrees to the left with his right paw, then put his nose under it and raised the long end to the horizontal position, exactly the movements necessary to let the door fall and release him. But, his head impeded the falling of the door. Then he thrust his right paw over the top of the door

and swung it down toward him. *The whole series of movements were members of a larger whole, the path-to-the-goal. One movement of necessity must follow the other, and be related to it as it is made, or it will not be executed.* This means that movements are conditioned, in their temporal relations, by the whole of which they are members. This whole is a general grasp of the problem which gives each movement significance as activity toward the goal. The cat's separate movements, instead of being pieced together into a sequence, differentiated out together, in an orderly series under an insight into the problem-situation.

In a string-pulling experiment, Tom walked around the cage, looked over the situation deliberately from all sides for two and one-half minutes, but not once attempted to paw through the side of the cage toward the food. Then he went to the front center of the cage, tried to pull in the looped end of the string and failed. On the next trial a stick was fastened to the end of the string. This time the animal spent only fifteen seconds in examining the situation, took the string in his teeth, turned his back on the food and jumped down from the ledge, keeping hold of the string. The food, however, caught on the cage, so that the cat was accidentally deprived of its reward.

Two trials later the problem was changed by tying the end of the string to the top of the cage instead of fastening the stick to the end of the string as before. When the animal confronted this problem he went directly to the top of the cage and attempted to secure the string in his mouth. Failing, he jumped down and looked over the situation. After doing this twice, he jumped to the ledge of the cage, caught a loop of the string in his teeth, and then tried to pull more of the string through the bars with his paw. Although the animal failed to accomplish this end, there is again illustrated an insightful response. The goal was not definite, nor the movement precise, but the goal was there and the movements were organized toward it. This is shown by his use both of claws and teeth in the effort to pull in the string.

Insight in the Cat. The behavior of the cat illustrated by this study shows conclusively that the animal was working under a tension; that its behavior was organized with respect

to a goal; that its response was not made to an isolated stimulus, but to a pattern of stimuli; that it exhibited evidence of sudden learning in the solution of the various problems; that this learning was on the order of making new discoveries, and that the animal was able to transpose from one problem to another in a way that might be called sensible. *All these are criteria of insight.* That the animal did not always solve the problem in the foregoing illustrations is no indication of a lack of insight. In most cases, errors were the fault of the experimental situation, not of the animal that has, from an evolutionary standpoint, a nervous system of only limited development.

Johnson on Dogs. Johnson [11] employed, in general, the same type of method with dogs. He constructed six kinds of puzzle-boxes, each with a different type of latch. The animals were to secure their food by opening the box. Johnson used two groups of subjects, one in which their eyelids had been sewed together in early puppyhood before the eyes had opened, and the other, a group of normal, seeing animals. First, he presented the blind animals with three of the puzzle-boxes. He placed the food in the box, then released the animal from a retaining cage some distance away. Second, a group, composed of normal seeing animals, faced the same problems with the same method as just described. The results of this part of the experiment showed that there was little difference in the problem-solving ability of the two groups. The blind animals were able to make the complicated adjustments required in the puzzle-box in seemingly as adequate a fashion as the seeing animals.

After the blind and the seeing animals had learned the first set of problems, rotation of the puzzle-boxes was introduced. Both the seeing and the blind were much disturbed by a rotation of 90 degrees. The problem was an entirely different one, requiring a learning process as did the original. But the dogs never reverted to the old position to search for the latch after they had once found its new position. Another 90-degree rotation of the puzzle-box, after the first change had been mastered, offered very little difficulty. When still a third 90-degree rotation was introduced, a marked difference appeared be-

[11] Johnson, H. M., "Audition and Habit Formation in the Dog." *Beh. Mon.*, 1913, Vol. 2, 54-78.

tween the seeing and the blind animals. (See Fig. 21.) The blind animals continued, after each change, to follow the same pathway around the box from the starting point, although after three rotations it was (unknown to the animals) the longest path to the door in the new position. But, when the third rota-

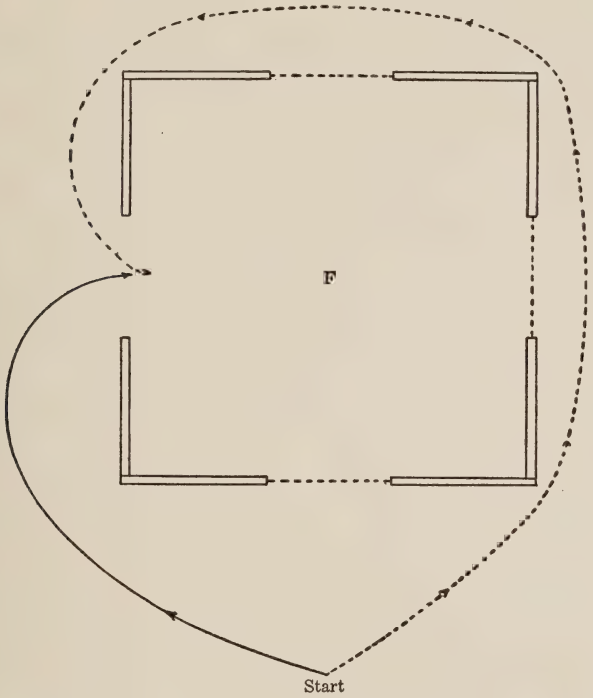

FIG. 21. PUZZLE BOX OF TYPE USED BY JOHNSON IN HIS EXPERIMENT ON DOGS.

Solid line represents path of seeing dogs; dotted line represents path of blind dogs, after third rotation of the box. By permission.

tion was made, the seeing animals went directly to the latch, after a few trials, over the short pathway. All of the dogs improved during the three transpositions.

This experiment demonstrates that although there was no appreciable difference in the rate of learning between the normal and the blind animals in the original problem-situations, quite decided differences appeared when the problem was altered by rotation of the maze. It would thus seem evident that, although

vision was not essential to the solving of the initial problem, it was of significance when complicated adjustments were required, as in transferring from one situation to another. The seeing animals obviously responded to a larger total pattern, and for that reason the altering of details did not disturb them appreciably. Because of their lack of vision the *blind animals* could not see this larger situation and therefore perceived each of the rotations as a relatively new, isolated problem.

The Perceptual Configuration or Perceptual Field. When we consider an insightful response from the standpoint of the animal's experiences at the time, it is convenient to say that he *perceived the total situation,* or developed a *perceptual pattern or configuration.* From its standpoint, the animal's perception of the problem-situation is a field phenomenon in which all parts are interrelated spatially and temporally. Hence it will be convenient, also, to employ the phrase, *perceptual field.*

Summary. The experiments described in this section have demonstrated that the animal responds toward a goal or remote end over the shortest route in time. This fact indicates that the response is insightful. Whatever the experiment, the goal and the route toward it were perceived only in light of a larger pattern of stimuli in which they had membership-character. Conclusive evidence is found in the behavior of Johnson's blind dogs that the direction in which the animal will adequately solve a new problem is determined by the completeness and comprehensiveness of the perceptual pattern out of which awareness of the goal and the path to the goal emerge. The comprehensiveness of perceptual patterns will be mentioned frequently in a subsequent discussion of the primates, including man.

Experimental Studies of the Lower Primates

Use of Tools in Goal-Activity. The most primitive means to an end in the goal-activities studied so far was the actual *movement of the animal in bringing itself to the end.* Thus, in the invertebrates and in the lower vertebrates, the animal could respond only in a situation that involved, as a means to an end, mass movement over a given route from a starting

point to a prescribed place in its environment. For example, the goldfish were required to swim from one place to another in order to reach the goal. But even this simple type of response involves the problem, How do movements obtain their *direction?* This in turn presupposes organization in terms of alignment of neuromuscular potentials that *give direction* to the movements. This organization, considered from the standpoint of the animal, is *insight.* In the higher vertebrates, particularly the dog and the cat, a more complicated response was observed. The animal, in this case, was not only required to move from one place to another in reaching the goal, but was also required to make certain manipulations of objects in a given place in order to reach the end. Yet the animal's movements must be organized toward the *same* remote end. The performance, including locomotion and manipulation, is one unitary process; and the response of necessity involves perceiving a larger and more complicated stimulus-pattern in its totality. The next step in the learning process, illustrated in the lower primates, involves not only all of the foregoing modes of response, but, in addition, the employment of a *movable* object as a tool.

Configurational Behavior in Monkeys: Tinklepaugh. The use of movable tools in reaching remote ends emerges from a type of behavior long known as the *delayed* response. Here the animal is shown the position of the goal, but before it is allowed to respond, the goal is covered, or the animal is turned away from it. Tinklepaugh [12] has investigated *delayed* response in the monkey. Four Rhesus monkeys were presented, first, with two grey cups six feet apart situated eight feet from a retaining chair from which the monkey started. The experimenter placed food in one of the cups while the monkey looked on. At the end of a given delay-period the monkey was released and allowed to secure the food. Delay-periods from 30 seconds' to 3 minutes' duration resulted in correct responses. Curiously the animal seemed inattentive to the food-cup situation during the delay-period, but, when released, would walk directly to the food.

[12] Tinklepaugh, O. L., "An Experimental Study of the Representative Factors in Monkeys." *J. Comp. Psy.,* 1928, Vol. 8, 197-236.

In a second experiment, Tinklepaugh attempted to disorient his animals. He presented them with the food-cup situation as before, but in the delay-period he placed them with their backs to the cups; nevertheless, when the animals were released they responded correctly as before. Even when they were removed from the room during the delay-period, and fed, they still responded correctly when brought back. In a third experiment a screen was introduced between the animal and the food-cups, after the food had been put in its place with the animal watching. The monkeys were somewhat disturbed by this new situation, but soon learned to solve the problem. Whereas the animal had heretofore gone directly to the food, it was now required to approach and encircle the screen before it could see the cups. Then it must choose the correct one. This meant that the monkey must remember, during the delay-period, the cup in which the experimenter had placed the food. This was relatively easy so long as the cup remained in sight but when the situation was complicated by introducing a screen or by taking the animal out of the room the problem was difficult even for a young child, yet the monkey was able to solve it.

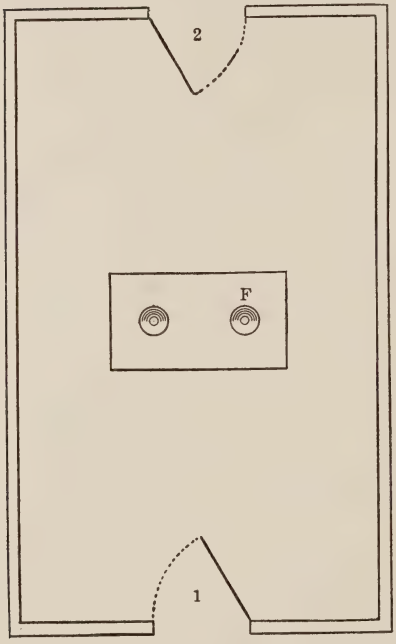

FIG. 22. DIAGRAM SHOWING PROBLEM WHEN POSITION OF MONKEY WAS REVERSED AFTER FOOD WAS FIRST DISPLAYED.

Note that the food is at the monkey's right in position 1 and at the left in position 2, to which monkey was moved after food was displayed at F with monkey at 1. After Tinklepaugh. By permission.

In a fourth experiment the monkeys were transferred to the opposite side of the room, after the food had been placed. Now

the position of the correct cup with respect to the animal *was reversed.* This situation confused all of the monkeys. One of them failed to solve the problem, but the others were finally successful. In this experiment the animal saw the experimenter place the food in the cup on the right, but when transferred to the opposite side of the room the food was no longer in the right-hand cup but in the left. (See Fig. 22.) Thus the food-cup must be perceived not only in relation to the animal but also in relation to the room, and to the position of the animal in the room. The perceptual pattern involved the whole room, the cups and the monkeys in relation to it, or the position of right and left could not have been apprehended in their reversed relationships.

Bingham's Work on Chimpanzees. Bingham [13] presented four chimpanzees with problems in which the indirect transportation of food was required for a correct response. He constructed a wire and metal cage, at the base of which, on all four sides, were small doors just large enough to admit the animal's hand. (Fig. 23.) The top of the cage was divided into four equal parts by a crossed track, and from this track extended a rod nearly to the bottom of the cage. At the lower end of the rod, food was fastened, and at the upper end, a ball that ran along the tracks. Thus, if one of the four doors at the bottom was open and the bar on which the food was fastened was at the other side of the cage, the chimpanzee must climb to the top of the cage and move the rod along the track, by means of the ball, until the food was within reach of the proper door at the bottom of the cage.

With this method numerous problems were possible; the food-bar could at one time be directly opposite the open door, requiring the animal to move the ball in a straight line to the opposite side of the cage. At another time the bar could be placed to the side of the open door, which meant that the animal must slide the bar to the center of the cage, parallel to the food, and then slide it along the track that was in line with the food.

After the apes had learned to master the problem with one door they were changed to another, on a different side of the

[13] Bingham, H. C., "Selective Transportation by Chimpanzees." *Comp. Psy. Mon.,* 1925, Vol. 5, No. 4, 1-45.

cage. When they were presented with this situation, strong evidence for adaptability in the light of a comprehensive situation came to light. Pan faced the old doorway, looked over the situation, went to the new doorway and reached in with his hand. Next, he climbed to the top of the cage, turned his back on the doorway and drew the bar toward him until it was in reach of the doorway, then jumped down and seized the food.

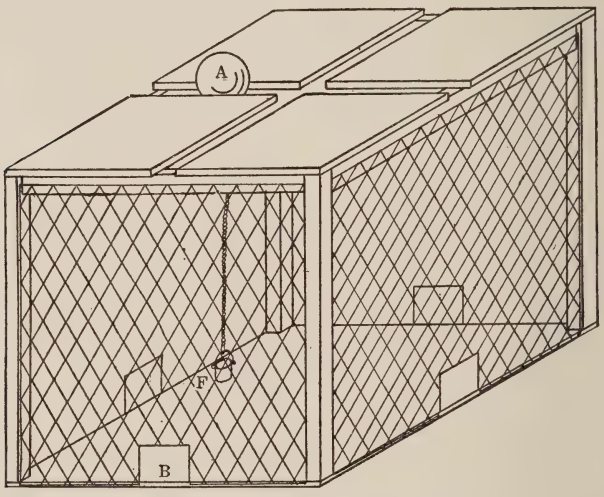

FIG. 23. SCHEMATIC DIAGRAM OF APPARATUS USED BY BINGHAM IN CHIMPANZEE EXPERIMENT.

The ball-handle marked A is moved by the chimpanzee down the groove toward the door that happens to be open (B). By permission.

Before he responded to the changed situation Pan showed by his behavior that he recognized the new position of the goal. He inspected the entire situation first, then made all of the new movements in a continuous, flowing series, one following the other in a unified, orderly performance.

That in using the ball as a tool the ape was able to turn his back on the food and still make the appropriate movements, is highly significant. It means that the animal was responding to the ball in the light of a larger set of relationships, one that contained, not only the ball and the goal, but the entire cage and the surrounding room as well, each with membership-character in the total perceptual whole.

Köhler's Work with Apes. Extensive experiments by Köhler [14] leave no doubt that the chimpanzee responds to one stimulus in the light of a total situation, with the use of tools. In one experiment Köhler placed a banana outside the cage beyond the animal's reach and laid a stick on the floor within the cage. This problem *seemed to be too difficult if the stick was not in the same visual field with the food.* This must mean that the animal was able to perceive the food and the stick in relation to one another, when these two objects were in the same perceptual pattern.

The experimenter then suspended food above the ape's reach and placed a box near by. Koko solved this problem very rapidly. When first confronted by the problem he jumped for the food without success. A few minutes later he moved away from the wall and approached the box. Then he glanced across at the food, and gave the box a push, but it did not move. His movements then became slower; he backed away from the box; then returned to it, after glancing at the food. Next he moved the box a very short distance toward the food. At this point Köhler made the goal more attractive by adding to it a piece of orange. A few minutes later Koko returned to the box, grasped it suddenly, pushed it in one movement almost directly under the food, climbed up and seized it. Subsequently, when the food was hung from another wall, the animal failed to solve the problem for several trials. He had not grown to the problem sufficiently to perceive the larger stimulus-pattern which included both of the problems as a unit. After the initial failures, however, the animal again solved the problem and continued from then on to transpose correctly from one situation to another.

Chica, another ape, exhibited striking evidence of insightful behavior. In one experiment she tried repeatedly to reach the suspended food, without using the box, when in similar tests she had employed boxes before. She was not ignoring the box for she would sit upon it repeatedly when out of breath. The experimenter noticed that, meanwhile, another ape, Tercera, was lying on the box. Shortly afterward, Tercera leaped off.

[14] Köhler, W., *The Mentality of Apes.* (E. Winter, Tr.) London: Kegan, Paul, 1924.

Immediately Chica dragged the box under the fruit and reached the goal. *The box on which Tercera was lying* was not an 'object with which to fetch the goal' but 'something on which to lie.' The box appeared to the ape in one set of relationships and did not possess other relationships at that particular time.

For another series of experiments Köhler constructed four hollow sticks of different diameters. Number 1 fitted into 2, 2 into 3, and 3 into 4. The apes learned to fit the smaller end of one stick into the larger end of the other. During practice they held the thicker stick passively in the left hand and fitted the thinner one into it with the right. With four sticks instead of two, two given him at a time, Sultan grasped the thinner tube at once with the left hand and the thicker with the right in eight trials out of twelve, but in the remaining four trials reversed the sticks before he made any attempt to fit them. *This meant that he picked up stick number 2 with the left or with the right hand, depending on whether he was to fit it into number 1 or number 3.* In turn, this means that the activity of fitting the sticks together was not that of associating one isolated size with another isolated size, but rather, that of perceiving the total situation of two sticks related in a certain way. The total perceptual pattern determined what the function of the given stick was to be in the process of fitting the two objects together. Making two 'random' movements and putting them together *can mean nothing in a situation of this kind because it presupposes that the movements are made, first, out of relation to each other, and then put into relation. The facts disprove such a conception, for Sultan did not make two unrelated or random movements first.*

Yerkes' Experiment with a Gorilla. Using a method similar to Köhler's, Yerkes [15] presented Congo, a gorilla, with various problems, not only for original solution but for solution one year after presentation. The gorilla had difficulty at the outset in solving the stick and banana problem, but when tested a year later, *solved it at once.* In another experiment the animal was presented with three boxes that measured 12, 15, and 18 inches, respectively. When stacked in the form of a

[15] Yerkes, R. M., "The Mind of a Gorilla. Part III, Memory." *Comp. Psy. Mon.*, 1928, Vol. 5, No. 2, 1-92.

pyramid they enabled the animal to reach its food. Congo solved this problem on the seventh trial. A year later he was given three boxes that measured 10, 14, and 18 inches, respectively. This time he solved the problem immediately, although the piling of the boxes was not perfectly carried out. In this experiment there is unmistakable evidence of maturation with respect to the problem, for improvement was shown after a long lapse of time.

In another experiment, Yerkes presented Congo with five differently colored cans, mounted on a wheel, outside the cage. By rotating the wheel with his hand the gorilla could bring any one of the five cans within reach. Yerkes placed food in one of the cans, for example the white one, then waited a given length of time before he allowed the animal to make a response. These experiments showed that Congo could choose the correct can after a delay of at least three hours, and that the response was in most cases sudden and direct in character.

The evidence from this experiment indicates that the gorilla was able to adapt more readily to new situations as he became more mature. The limitations of this adaptability appeared, however, in the box stacking experiments, where he solved the problem very rapidly if the box-and-food situation was under a familiar tree, but when the same problem was presented under a strange tree he required several additional trials. This would indicate that the animal was not responding to the boxes and the food in isolation, but that he perceived them in relation to a larger stimulus-pattern, which included the tree and the surrounding environment. It was not until the animal could apprehend the two situations as parts of a larger, total pattern, that transpositions could be made.

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CHAPTER VI

PRINCIPLES OF MENTAL DEVELOPMENT DERIVED FROM ANIMAL STUDIES

Organismic Laws and the 'Selection of Response'

The outstanding problem in connection with the psychology of learning has always been, How are the successful responses 'selected'? The preceding investigations on animal behavior have answered this question. The 'selection of responses' takes place under the laws of dynamics, which have already been found to hold in case of the developing embryo. This is not surprising, for certainly one would not expect the nervous system to obey different laws, in an experimental learning situation, from those found to hold for neural growth. Moreover, there is no selection in the sense that certain responses are actually 'picked out' of several alternatives, and others 'eliminated.' There is no 'juggling' of responses. They occur or they do not occur. 'Selection' is merely a figure of speech. It means 'occurrence,' and nothing more.

The Law of Field Properties. The problem of 'selection' reduces to laws of organization the first of which is the law of field properties. From the goldfish to the ape a certain property of behavior was invariably demonstrated, namely, the property of insight. The solution of a given problem always turned out to be a *unit-process;* it possessed an organization unattributable to any single event into which the process could be analyzed, and this organization pertained not only to the space relations of the responses involved in the solution, but to their temporal relations as well. This fact held all the way from the original perception of the goal to the final mastery. Both organization and insight were characteristic of the total performance at any stage of its development. They are therefore field properties. Nothing determined the *'selection'* of insight except the difficulty of the problem for the animal. This meant

that insight was a product of growth or maturation, and a function of the degree of 'fitness' between the problem-situation and the organism's stage of maturation, considering the animal either at a given stage in the evolutionary scale, or at a given period in its individual development.

Since all learning is insightful, responses are not selected through their frequency of occurrence. In fact, frequency of occurrence has nothing to do with their 'survival.' Moreover, movements are not at first made separately and then put together. The learning achieved by Higginson's rats when the door in the circular maze was opened could not be characterized as a gradual elimination of unnecessary movements; each response was a new one, having a new field property, for it was a new configurational pattern. This was demonstrated when the rat made right turns into the doorway instead of the left turns that had been made 100 times previously. *The new response did not contain the old movements because the part of the maze that made the old movements necessary in attaining the goal was no longer present.*

These facts are profoundly significant for Education. They mean that each step in learning is a total pattern of response, not reached by assimilating new elements into an old pattern, but by a totally new organization made in response to a stimulus-pattern perceived as a whole in a new light. Tasks are learned as wholes. Unfortunately educational practice is generally based on the opposite assumption, that learning evolves piece-meal.

The Law of Derived Properties. The law of derived properties relates to 'selection' in that no response will be made unless it fits the total pattern of behavior already formed with reference to a particular goal. Consider the case of Révész's chicks. How were the walking movements made that brought the chick to the proper figure from which to select its food? The total pattern of behavior was a response to a pattern of sizes. The separate movements were made in accordance with the animal's perception of size, and the size of a given figure was a derived property. The object was not merely a certain large figure, but *one that was larger than another.* The property of a specific largeness was derived from the character of

the chick's entire perceptual field. In the illusion test at the end, there was no property of largeness when the parts were seen in isolation, but, when the parts were seen as members of a larger pattern, this larger pattern conditioned the property of *larger-than* in one of two figures which were actually the same size.

In like manner the goldfish and the rat could only have responded to a light that derived its property from a perceptual field. Being brighter than two others, or the middle of two, or the dimmer of two, was a property determined by the total perceptual pattern. That this was true became evident when the animals were transposed up and down the brightness range. The correct responses still continued; the animal, trained to choose the brightest light, still chose the brightest light. This was not because it had responded to an absolute brightness, for the total pattern was still giving to that light the property of being brighter than two others, and insofar as the animal was responding to a total situation, this was still the correct response.

The law of derived properties is another reason, therefore, why a movement must fit into a general plan *before* it will be executed. Swimming or running toward a particular light must carry out the plan represented by the total behavior-pattern, in this case an effort to secure food somewhere in the apparatus. Whether the movement will fit or not depends on how the animal perceives a given light in relation to the others. In short, the movement emerges from a total pattern, 'fitting' as it emerges.

Adams' cats offer further illustration of this law. The movements of the cat's paw and head, and the position of one paw with respect to the other in pulling the string *had no significance in their own right.* They were all part-activities, significant only with respect to the total pattern to which they were subordinate, a pattern of behavior including body posture, perception of the goal, and the path to the goal, as well. It was the larger totality of body movement that, through its organization, gave to the movements of the paws, the head, or of any part, their property of being 'the right way.'

These facts have their significance for Education. They

show, for example, the necessity of achieving tasks by the whole method in order that various parts of the task will take on the proper meaning. Parts derive meaning in no other way. Thus, in learning to read, sentences derive their meaning from the theme of a story; words derive their meaning from the complete thought of a sentence or phrase, and letters their meaning from words. Individual numbers acquire their mathematical values from ranges and series of numbers; a tone derives its perceived pitch value from acquaintance with a tonal range; individual colors from a color range. Size and position of objects are learned by first perceiving a spatial field.

The Law of Determined Action. This law states that the whole governs the activities of its parts and explains why parts take on derived properties. Hence, illustrations of the preceding law are relevant to this one. The learned act at any stage of its development is a total behavior-pattern that *determines* what the detailed responses shall be. In Adams' cats, movements toward the latch, paw movements employed in lifting the latch, movements of holding with the mouth, and all the rest, were never initiated as originally meaningless and isolated movements, later to become significant. They were all movements conditioned and initiated in a grasp of the situation. A total perceptual-motor pattern guaranteed the rôle of each movement as means to a goal.

Johnson's dogs offer further illustrative material under this law. The seeing animals changed their course when the box had been rotated 270 degrees, but the blind animals did not. This was because the former perceived more comprehensive relationships at the outset; their perceptual configuration conditioned, throughout, what paths were to be taken in attaining the goal. The blind animals perceived more limited relationships and thus took *the same* path, throughout, although in the end it was the longest. In either case, the responses were determined by the extent and character of the *perceptual field* formed by the animals in responding to the box and its surroundings. In Köhler's apes, perceived relationships determined the movements made in fitting two sticks together. If the smaller stick was number 2, to be fitted into number 3, that stick was grasped in the right hand, and the larger in the left;

but if the stick presented with number 2 was number 1, then 2 was grasped with the left hand and 1 with the right.

Applied to Education this law demonstrates the inevitableness of defeat unless the whole method of learning is employed. Indeed, it means that tasks will be mastered by wholes whether or not instructional techniques fitting such a method are employed, and that when not employed, any progress that is made comes about in spite of, not because of, the methods imposed upon the learner.

The Law of Individuation. That parts emerge from wholes through a process of individuation is the fourth organismic law. The beginning stage of any growth process, whether it be development of the nervous system, or whether it be a case of learning, is characterized by a lack of differentiation. This lack of differentiation reveals itself, in animal experiments, in the animal's first vague perception of the imposed problem, where the prescribed goal and the path to it have not yet definitely emerged. The final accomplishment is achieved when the total pattern has developed to the point where the goal, the path to it, and all the necessary movements have differentiated out together, each movement deriving, as it emerged, membership character in the total performance.

In Adams' experiment the observation was made repeatedly that once the cat discovered the way out of a box without definite insight into the detailed procedure of escape, its movements from then on were *in a general way directed* toward the mechanisms that opened the door. Here we find an excellent example of an undifferentiated, but unified, total response toward an indefinite goal. The animal's progress was made in terms of definitizing *these* responses. In Köhler's stick-fitting experiment the same cycle of responses was evident. The ape's first movements were gross in character but at no time lacking in organization. Apparent fumbling was executed as a mass movement toward the end of fitting the sticks together. The finer and 'better' co-ordinated movements, characteristic of the perfected response, appeared in *one* differentiated pattern of movement with each detail executed in relation to the others. As it emerged, each came in the right place as the space problem was being solved, and each came at the right time as the prob-

lem of correct sequence was being solved. The movements followed upon a differentiation of the ape's insight into the nature of the problem. Thus it turns out that the law of individuation is a law of 'selection' because responses *come into existence already 'selected' and integrated.*

Educational procedures that do not recognize this law are always ineffectual, for the reason that they do not permit the emergence of detailed meanings on the one hand, and the more refined motor co-ordinations, on the other, in relationship to each other. As a consequence learning is retarded and superficial. Much of the difficulty that pupils experience in school subjects is traceable to this source, especially the difficulties encountered in grammar, spelling, and mathematics.

The Law of Field Genesis. The law of field genesis is an important law of 'selection' because, at any stage in the development of a given behavior-pattern, any stimulus-situation to which the organism will respond is relative to the status of the behavior-pattern. That is, at any stage in the evolution of behavior with respect to a given problem, the stimulus-pattern takes on more meaning, and will be responded to in such a way that more of the stimuli will be observed. To illustrate, when a novice looks for the first time into a miscroscope he fails to observe the fine shadings in color and distinctions in form of the tissue in the microscopic field. This does not mean that the light rays are not all being responded to, but that their total effect is at first undifferentiated. Later, the color field becomes differentiated, but it is the same general field as was perceived at the outset.

This same fact was evident in Adams' cats. Physically, the stimulus-pattern did not vary throughout the learning process. But in the beginning, the total effect of the various brightness values of the objects to be manipulated, their forms, and their space relations, *was* general; the details were not seen. Later, when the cat could perceive differences in the brightness and form of the objects, the stimulus-pattern had not changed, but the relative values of its details had changed. This was because the animal's perceptual field had evolved and differentiated. The stimulus-pattern had induced, in this particular situation, a growth process. A stimulus functions in eliciting

a response, therefore, only when it has a certain value for the organism, a value which depends upon the organization of brain processes at the time.

There is another way in which field genesis becomes a condition for the 'selection of response.' The growth process is sudden when the stimulus-pattern presents relationships to the reacting organism that 'fit' the evolutionary stage of its behavior-pattern. Because learning in the goldfish was configurational and involved the perception of relations, there was a sudden elimination of 'errors.' Adams' cats did not differentiate their gross movements gradually. When they perceived the relationship of a button or a latch to the food-goal, they merely left their hunting and searching movements behind, because these movements were no longer relevant to what the cat was doing. This fact was clearly brought out in Higginson's experiment where the rats eliminated a long route to the goal the instant they discovered a shorter one. The 'selection' or occurrence of new movements is a matter of perceiving new methods and relationships. The new movements are a consequence of increased insight when the new path to a goal becomes obviously more 'sensible' than the old. The development of insight takes place as an expanding comprehension of the same problem as that with which the animals commence.

Gengerelli's rats also demonstrated this law. At first their orientation to the checkerboard problem was vague and indefinite. They wandered about, searching for escape or food. The goal was first discovered only in its general relationship to the maze pattern as a whole, but this sufficed to shorten the animal's path. Then, with additional exploration, orientation became more complete. In terms of the rat's perceptual field this meant the simultaneous discovery of detailed space relationships of smaller and smaller parts of the maze-pattern. The perceptual field was expanding as an indivisible, unitary 'picture.' The orientation complete, the path to the goal had been shortened to its limit. *Direction of movement has followed,* naturally, upon perceptual orientation. 'Dropping out' means 'no longer made.'

The law of field genesis demonstrates the artificiality of piecemeal learning, and points to the importance of providing

the learner, first, with a simple task which, instead of being repeated, should be expanded, gradually, in such a way that the unity of the task is preserved, a constant relation or principle brought out, and more and more detail admitted.

The Law of Least Action. The problem of 'selection' can be understood best of all, perhaps, under least action. One set of movements in any problem-situation is forsaken for another because the latter provide a shorter route to the goal. The shorter route means the expenditure of less time and energy. *No energy system needs to be taught this principle; it obeys the principle.* Inevitably, the animal or the human learner takes the shortest route to the goal which it is able to perceive under the existing conditions. When it maturates to the extent that it can discover a still shorter route, it will inevitably take it. If the plan of the apparatus is changed and the problem reduced to the animal's level of insight, shorter routes are chosen immediately. The organization of movements toward the goal will take care of themselves.

The law of least action explains the *directional character* of the organism's activity. The learner is constantly headed toward some goal, over the shortest route in time. The complicatedness of the problem with respect to the learner's insight determines what the route shall be. The significance of these facts can be appreciated only when 'co-ordinated' or 'integrated' is understood as 'directed toward an end.' A complicated system of energy is conditioning the activities of its parts under the law of least action. Thus there is only one method of making desirable co-ordination possible, namely, the method of reducing a task to the level of organization represented in the learner. If this condition is provided, the co-ordinations need not be 'learned' through practice; they are invented or discovered; they are made perfectly the first time. Recall how motility developed in the embryo! Conditions can be furnished any learner, therefore, so that 'practice' in the ordinary sense of the term is unnecessary. This fact is based upon the physiology of the nervous system, and the sooner recognized by educators, the sooner improvements will come in Education. The principle applies in learning where ideas are involved just as it applies to motor skill.

Higginson's rats demonstrated this principle when by turning to the right instead of to the left, they forsook a long repeated set of movements for a set which brought them more quickly to the goal. Helson's rats climbed a partition of their own accord; Johnson's seeing dogs, with no practice, substituted for a round-about path to the right a short path to the left; Lashley's injured rat rotated 270 degrees to the right three times in reaching a goal when she was unable to make a left turn; Gengerelli's rats continuously shortened their path across a checkerboard maze as they became more oriented to the maze as a whole. The law of least action demonstrates the inefficacy of repetition as a condition of 'selection,' and that our whole conception of learning must be changed because a learning organism is a complex, dynamic system of energy, obeying the laws which apply to energy anywhere.

The Law of Maximum Work. The law of maximum work is, again, a law of 'selection.' Those responses will be made which *best* relieve the organism's tension toward a goal. This is because any form of stimulation disequilibrates the entire nervous system. That which disequilibrates it the most will dominate the response. Thus, if the shortest known route through a maze brings the animal nearer the experimenter and the animal is more afraid of the experimenter than he is hungry, he will take a longer route, where available, in order to avoid the experimenter. Helson's rats climbed a partition in order to avoid a grill, when passage over the grill was spatially a shorter route to the goal.

The law of maximum work may be seen in another light. At all times the organism is doing its best under the existing conditions. But where the tension is higher, there is more available energy. This is why learning is more rapid, in animals, when the hunger tension is greater. There is more energy to be expended in the search for food, and, at the same time, under the law of least action, it will be expended more rapidly. Other things being equal, therefore, learning will be faster. This is the secret of all forms of motivation.

The Law of Increasing Energy. The law of maximum work explains why an animal or a human learner achieves more when the goal is near than when it is far away. Recall again

the behavior of a falling body. It is resolving potential energy in the course of approaching a remote end. The nearer it approaches the end the greater becomes its kinetic energy or power to perform work. Similarly, the maximum energy available for human achievement increases with nearness to the goal. Human beings demonstrate this law each time they postpone an unpleasant task until the last minute *when it must be executed.* The goal is near, which means that, now, they have sufficient energy to overcome the inhibiting force of distracting goals. With approximation to the goal, the necessity of the demand reveals itself in the realization that the task *must be* completed. This is exactly like the greater momentum with which a body, having fallen a long distance, strikes an obstacle, as compared with the slight jar with which it strikes when it falls only a short distance. In the former instance it is nearer its remote end. This principle is a corollary of maximum work and may be called the *Law of Increasing Energy.*

The law of increasing energy explains why animals and human beings, alike, frequently master the last movements of solving a puzzle sooner than the movements made when farther from the goal. This is because the greater energy available for work expresses itself not only in faster and more vigorous responses, but *in a higher degree of insight.* There are many individuals who can think best when under the emotional excitement of an argument. Their goal is immediate; they are keyed up with a desire to outwit their opponent. Nearness to the goal means a raised level of intelligence.

The Law of Configuration. The law of configuration, like all the other organismic laws, is a law of 'selection.' It means first, that no response will be made unless in relation to the problem as a whole; second, that no movement will follow another in a sequence unless the meaning of the total performance, from beginning to end, is understood by the learner. The path must be guaranteed from its beginning to its end before a single act will occur. Then, as the perceptual field becomes differentiated, the movements take their place in serial order, already organized toward the goal. If this condition for movement is not satisfied there will be no response.

The fundamental unity of response, no matter how complex the act, was demonstrated in all the animal experiments, because the subjects learned in a configurational fashion. This was evident in Bingham's chimpanzee, Pan. When a new problem was presented, he looked over the *entire situation,* climbed to the top of the cage, turned his back on the food, drew the bar toward him until he was in line with the doorway, then jumped down and secured the food. Not one of these movements was distinct in itself; each seemed to follow or 'flow' from the preceding one. It was evident that in one glance the animal saw the goal, the stick, the cage, and the path to the goal, all in their proper relationships.

Tinklepaugh's monkeys could never have solved their problems, with delays and changes of position, if they had not responded to a *complicated* stimulus-pattern which *included* the chair, food, food-cup, wrong cups, and the *entire room,* all in relation to each other. Indeed, so inevitably is learning based upon perceiving one detail of a situation in relation to its setting that Yerkes' gorilla could not solve the box-piling problem, at first, when he was moved under a different tree. This law is observed to operate in the feeble-minded who can be taught to play chess! They are successful so long as they can use the men with which they learned the game, but they are confused when given men of different size and shape. In fact, tying pink ribbons around the necks of familiar men may spoil their game entirely. The law of configuration limits responses in accordance with the comprehensiveness of the whole in which a particular response can be learned. Stereotyped reactions do not mean that the organism is not responding configurationally, therefore; they merely mean that the perceived relationships are restricted in their scope.

Contributions of Animal Studies to a Practical Psychology of Learning

Major Characteristics of the Learning Process: (1) Directionality of Response. A genetic study of the learning process through the animal scale has brought to light the

fundamental principles of learning. First, learning involves a modification of behavior, but this modification is not a mechanical procedure, even in simple animals like the ameba. *The animal contributes the modification in the course of arriving at a certain end.* Although the type of behavior observed in a simple animal of this kind is only that of the *transportive type* where the animal changes the character of movements that are confined to locomotion (the ameba's movements of eating and locomotion are similar in character), *these movements are means to an end.* This does not imply that the animal plans its behavior as human beings do. It means, however, that it executes them under the same laws that pertain to planned movements, the laws of dynamics.

The first major fact of learning, therefore, evident at the outset in the animal scale, is that *movements are directional.* Complexity of response is irrelevant to this principle. Movements, whether simple, like those of the ameba, or complex, like those of the ape, are directional; they are made in the course of resolving a stress of some kind toward equilibrium.

(2) Directional Response to Alternative Stimuli: Choice and Insight. The second important fact derived from the preceding animal studies is that directional activities occur where discrimination is involved. This type of directional activity was present as low down in the animal scale as the goldfish. The goldfish made a choice between three lights, a type of behavior revealing some very important facts for an understanding of the learning process. A choice involves the perception of one stimulus in its relation to others, or in other words, it involves insight. All along the animal scale the evidences of insight were the same: modifiability of behavior in new situations resulting in correct responses the first time; transposability; response to total situations.

The Importance of Insight. Before modern psychology can adequately be applied to Education the problem of *insight* must be thoroughly mastered, for, first, it means that the essence of the learning process is *discovery,* the continuous doing of something new. Second, it means that greater care should be taken in selecting tasks for the learner to master, for

any task which 'requires repetition of response' is one improperly imposed upon the learner. Third, it means a substitution of *pacing* for drill. Tasks, graded in difficulty and complexity, should be selected in such a way that, each time, a perfect response is made with a single repetition. Fourth, it necessitates a marked change in mass methods of education where spontaneous activity of the child is reduced to a minimum. If the essence of the *learning* process is discovery, *learning must come about by way of creative work.* Where drill methods are employed the child learns through making discoveries if he learns at all, but his progress is retarded. Fifth, the concept of insight demands a change in the psychology of motivation. This problem is sufficiently important to justify a special section later on. Sixth, classroom instruction must be based on the laws of insight because the child learns by means of discovering principles no matter what his formal mode of instruction may be. Seventh, it means that fitting the task to the learner's level of insight involves not only a regard for the proper difficulty of the task, but for its meaning-value for the learner. The task must fit the learner's culture, when the learner is a child, just as an animal problem must fit the animal's natural mode of living and acting if a solution is to be expected.

(3) Specialized Movement as Means to an End. The third major point derived from a study of learning in the animal scale is that *specialized movements are made in the course of arriving at goals.* Examples of these movements are: lifting a latch, pulling a string, turning a button, and lifting a lever. The animal was obliged to learn such an act in relation to a situation under the same laws that the goldfish learned to perceive one degree of brightness in relation to a pattern of lights. Specialized movements of this type have been observed as far down in the animal scale as the cat and the dog. The problem necessitating these movements is more complicated than the problem involving the lights, but notice that in both cases relations are involved. The turning of a latch or pulling of a string must be accomplished in a situation that involves space and time relations to a goal. The movements must be made in a certain sequence and in different positions in space, all, how-

ever, in the course of arriving at a pre-established end. Here the relationships are more obscure and less direct. This means that the insight involved in solving the problem is of a higher order, and this higher order of insight comes with a more highly differentiated nervous system. The relationships involved in making these specialized movements are less direct because, in the case of the goldfish, choosing a light of a certain degree of brightness brought the fish immediately to the goal, while in case of latch lifting, or string pulling, there were still other relations to be perceived and other movements to be made. We are watching the learning process increase in complexity, but strange as it may seem, we have not encountered any additional principles. In each step in the evolution of the learning process the same number of laws are applicable. *Nature executes simple and complex performances in accordance with the same general plan.* When the child and adult human being are studied no additional principles will be encountered.

(4) The Use of Movable Tools. The next major point, and one which illustrates a definite stage in the evolution of the learning process, is that problems are solved with *the use of movable tools.* Here, as before, no new principles are involved. There is still the necessity of perceiving one part of a stimulus situation in relation to other parts, but the relations have become more complicated. The movable tool is one which may be used in variable space and time relations with respect to the goal, but the relations all have in common the principle of means to an end.

An ape employs a stick with which to draw in food from beyond arm's reach; he piles boxes in order to reach food too high to secure by jumping; he fits two sticks together in order to make a tool long enough to reach food at a distance. In all these performances we have evidence of an advanced development of insight, because the relationships which must be perceived are relatively abstract. The tool is an object isolated with respect to the goal. The relationship must be perceived in the course of a *strikingly creative* type of response. All of these facts may be summarized by the statement that, in the animal kingdom, there is observable a definite evolution of *creative insight.* It is this fact that should determine the atti-

tude of Education toward the child. Learning, any form of achievement, is *creative*. This is a law of organic life.[1]

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[1] The sophisticated student of Education will find little that is new in many of the conclusions regarding practical methods mentioned in this Text. This is because the better methods have evolved in Education in direct defiance of prevailing psychological theory. This explains the apparent discrepancy between the newness with which psychological fact and principle are here presented and the familiarity of the practical suggestions that follow from them.

CHAPTER VII

BEGINNINGS OF LEARNING IN THE CHILD

Maturation

The Historic Problem of Instinct. The problem of how the learning process commences in the child raises the question of instinct. Does learning, an 'acquired' form of behavior, begin with inherited modes of response that may be summarized by the phrase 'original nature'? The distinction between instinct and learning was made, originally, under the assumption that each evolved and ran its course in a different manner. But it has been discovered that behavior follows laws of dynamics; there is, therefore, no 'original' *versus* acquired nature, for the modes of response indicated by the terms instinct and learning follow the same laws. They arise and run their course in the same general manner. It is no more or no less 'instinctive' to eat, to walk, to protect oneself against danger, to beget offspring and to care for them, than it is to read, write, paint and reason.[1] Every performance of man or animal must have been acquired through maturation; every performance is dependent at all times upon a growth potential, and the growth potential depends upon environmental stimulation. The learning process, in general, is but a continuation and expansion, under environmental stimulation, of those growth processes and types of response which have been going on previous to birth. The first step, therefore, in understanding the beginnings of learning in the child, is to investigate the forms of behavior exhibited by an animal at birth.

Different Degrees of Maturation at Birth. Animals differ widely in the degree of maturation exhibited at birth. Certain birds, like the pheasant and quail, are ready to walk and run almost immediately after they escape from the shell, while

[1] For facts against the instinct hypothesis, see Wheeler, R. H., *The Science of Psychology.* New York: Crowell, 1929, Chapter VI.

the young of the robin and crow are practically helpless. At birth, the young rat is a blind, hairless, helpless creature, while the guinea pig comes into the world with hair, good vision, and a system of nerves and muscles sufficiently maturated to permit many kinds of activity. Again, kittens and pups are far less mature, relatively, than calves, colts, and new-born pigs. It should be evident that co-ordinations like those of walking must be acquired in accordance with the same laws whether maturation takes place before or after birth, yet it is still the common belief that repetition of performance explains walking in the one case and that instinct explains it in the other. Now we know that learning to walk in the case of offspring born helpless, awkward though the movements are at first, is a function of maturation and stimulation, and that repeated efforts are the consequences, not the causes, of learning.

Maturation in the Human Fetus. Coghill has recently collected evidence from scattered studies of the human fetus,[2] showing that before birth, motility of the body develops just as it does in the salamander. The earliest movements of the fetus are of the organism-as-a-whole. Movements of the mouth are observed to appear first, along with leg movements, and not until the organism is much larger, will opening and closing of the mouth take place in the absence of other gross body activities. The first leg movements occur as aspects of mass action; movements of the eyelids take place, initially, along with body movements; the first respiratory 'reflexes' to be observed take place along with opening of the mouth, movement of the head from side to side, and movements of the arms and legs. It can no longer be said, therefore, that complicated movements of the human being arise through a blending and concatenating (seriating) of 'separate,' local reflexes. These do not co-ordinate in man any more than in the salamander. Local reflexes individuate from total patterns of behavior; *once emerged they remain so.*

[2] Coghill, G. E., "The Early Development of Behavior in 'Amblystoma' and in Man." *Arch. Neur. and Psychiat.*, Vol. 21, 1929, 989-1009. See also, Wheeler, R. H., *Readings in Psychology.* New York: Crowell, 1930, Reading XXVII.

Motor Development in the Child

First Activities of the Infant: Irwin. Irwin [3] has recently described the behavior of the infant during the first ten days after birth. His observations are strictly in line with those made by Coghill on the salamander and human fetus. The infant's first movements are, in the main, performances of the organism-as-a-whole. From this mass action there have begun to emerge certain specialized movements of the body, such as breathing, sucking, grasping and crying. But these activities have not yet individuated sufficiently to take place in the absence of observable body movement. For example, the infant cries only as it waves its arms and legs and wiggles. Furthermore, specialized movements develop more rapidly in the anterior part of the body, involving the neck, face and arms, than in the posterior part. This fact harmonizes with what is known of the anterior-posterior physiological gradient and its influence upon maturation. As maturation proceeds the mass action required for local movement becomes less overt and more on the order of total body postures (stresses, tonus, muscular tensions), but these are always forms of mass action, and there are no specialized, local muscular contractions that do not depend upon them.

The human anatomy is extremely complicated. A performance of the organism-as-a-whole is bound, then, to be more variable in its appearance than the simpler body motion of a salamander embryo. Depending upon the initial position of the infant, mass action at one time will involve arm and leg movements that look quite different from movements made when the body is in another position, because of numerous mechanical factors that enter into the situation. To this extent, therefore, they may be regarded as 'chance' performances, merely because they are not predictable, *but they are not random. Being undifferentiated is entirely different from being random.* For example, if one took into consideration nothing but the infant's hand, its movements would appear to be random

[3] Irwin, O., "The Amount and Nature of Activities of New-born Infants Under Constant External Stimulating Conditions the First Ten Days of Life." *Genet. Psy. Mon.*, 1930, Vol. 8, 1-92.

simply because they would be observed erroneously out of relation to the whole of which the hand movement is a related part.

Irwin's study and many other observations less systematically obtained prove that any performance is an orderly affair when the whole situation of which the movement is a part is carefully observed. Organization is primary, and if, seemingly, there is a lack of it in the infant's local movements, there is only one possible conclusion, namely, that the observation is incomplete. It is important to remember this conclusion, for otherwise the student will be certain to miss the point, later, when he studies the development of skill and thinks that he has discovered genuine random activity.

Learning to Walk. Little Johnnie, about a year old, is playing on the floor near a chair. Grasping a leg of the chair he pulls himself into a standing position and leans, uncertainly, upon the chair-seat. He looks around him, straightens up, releases his hold on the prop, and takes a step forward. He totters for a brief instant, and then collapses to the floor. A little later he tries again and succeeds in taking four or five wobbly steps before falling backward with a thud. After a few weeks he is able to walk quite steadily. In popular parlance, Johnnie has learned to walk *by means of* a try-try-again procedure.

But here is Bob, whose parents were afraid that he might become bow-legged, and have kept him off his feet for several months beyond the period during which Bob might have tried to walk. The time now ripe, Bob is given his freedom. He grasps the leg of the chair, pulls himself into a standing position with a precision quite uncharacteristic of Johnnie, and launches out across the room with unfaltering steps and balance of his entire body equivalent to many weeks of 'practice' on Johnnie's part.

In some respects, age for age, Johnnie may be superior to Bob; he has had more exercise and his muscles are stronger, not because they have contracted more often and more vigorously, but because the total set of conditions that have induced muscular activity have increased his heart action; given the muscles a better blood supply; improved the composition of his blood; and have induced maturation of the muscles. Doubtless as a consequence of his greater activity he has been breath-

ing more deeply; has been in more sunlight; and has eaten more heartily than Bob. His nervous system, as well as his muscles, has undergone greater development in the course of, but not because of, use.

Learning an Expression of Maturation. Johnnie's behavior is not to be explained on a different basis from Bob's behavior. It makes no difference whether or not maturation goes on for a time with, or without, 'practice.' Where efforts occur, as in Johnnie's case, we have evidence, not of random and unsuccessful activities, but of orderly responses of an undeveloped, undifferentiated nervous system. There is no more reason for regarding Johnnie's final success in walking as a product of experience than for regarding Bob's success as a product of experience. Johnnie had more experience than Bob in acquiring the walking co-ordinations, but they were consequences, not explanations, of his learning to walk. They occurred as expressions of a maturing system that was permitted to function while it was maturing. Bob was not permitted the expression. This is the only essential difference. Recall the rat and the guinea pig!

Analysis of Walking. Careful observations of walking movements prove what has just been said. The first efforts to walk, like the movements of the embryo and the new-born infant, are mass actions. No one ever saw a young child put one leg before the other with arms, head and trunk relaxed. No one ever saw him move one leg, then the next, then combine the two movements, and finally, add contractions of the back and abdomen to the contractions of the leg. On the contrary, observations of his movements yield facts that are just the opposite. The body-as-a-whole is in action and the various parts function together in a unified, total pattern. This pattern is undifferentiated at first because the child attempts to walk before maturation is sufficiently complete. This gives to his movements their apparent awkwardness. 'Awkwardness' does not describe movement scientifically. It is a term applied to one movement when it is compared with another, made at a later stage in the learning process. But the earlier and the later movements are made under *different* sets of conditions, hence it is illogical to compare them.

Mass Actions and Posture as Requirements for Walking. Suppose that the movements of walking were at the outset discrete contractions of muscle-groups in all parts of the body, and suppose that these movements must be pieced together. What if the parts did come first and the whole were built up as a summation of the parts? There are muscle-groups in the neck that hold the head erect; there are muscle-groups up and down the back that function, in walking, to keep the body erect; there are muscles in the legs necessary for making the stepping movements; in the shoulders and arms there are, finally, muscles that aid in maintaining the proper center of gravity while the body is in motion. The first fact against the piecemeal theory of walking is the impossibility of contracting all of these separate muscle-groups individually. The muscles of the back must be functioning while the legs are moving. Let an adult try to walk with his head bent sharply against his chest and he will discover at once that walking is not, alone, more difficult for the want of vision ahead, but it is actually more difficult to contract the legs. A certain *posture* is necessary for walking, and posture is a mass activity of the body-as-a-whole. This posture is changed when the head is bent against the chest.

Second, if walking were constituted of so many separate movements combined into one, through what agency are the various contractions properly timed? There is nothing in any of the separate movements that furnishes a timing device. A little thought will lead directly to the conclusion that the proper temporal relations of the various movements can be guaranteed in only one way, namely, by the individuation of these movements out of a total unified pattern, the timing determined by the pattern. This was what Coghill found in the salamander. The movements of all four legs were timed by waves of flexion that alternately passed down the body of the animal into the legs. Thus it can be seen that there is no possible way by means of which a complex whole can be built up from its parts. Growth proceeds the other way.

Origin and Consequences of the Total Behavior-Pattern in Human Beings. From a single behavior-pattern which gives to the infant his posture, there emerge all the movements of walking, organized as they emerge. This pattern dates back

at least to the time when the fetus is less than two inches in length. At this stage the nervous system and muscular tissue are sufficiently developed to permit response, and the response is mass action. During the later stages of uterine development, the behavior-pattern is expanding and differentiating in general as Coghill found it in the salamander. This embryonic growth continues until the death of the organism. The pattern is rapidly expanding and differentiating through the maturation of nerves and muscles during the first few months of the infant's life. Evidences of this fact are seen in increasing precision of grasping and holding; in carrying objects to the mouth; in acquiring the sitting posture; in creeping, speaking, and finally in walking. It is from this same total behavior-pattern, continuing to expand and to differentiate in the course of further maturation, that skilled performances of all kinds emerge, such as movements made in eating at the table with knives and forks; the movements of dressing and undressing; the movements of writing, singing, playing games, and the intricate co-ordinations involved in handling machinery and plying trades. The history of any skilled performance is the same. The first movements are general and undifferentiated, but not random. The finer co-ordinations emerge from the grosser ones, organized as they emerge.

Development of Intelligent Behavior

Character of the Infant's First Experiences. All available evidence points to the fact that the infant's first experiences are quite analogous to his first movements. They are not, as one might be led to think, discrete, specialized experiences of seeing, hearing, and touching. They are undifferentiated, indefinite experiences of total situations, the consequences, first, of mass stimulation over a variety of nerve channels leading to the brain from a variety of sense organs; and second, of an undifferentiated nervous system that receives the effect of these stimulations. Thus, the first experience is a *field,* or *ground,* comparable to undifferentiated muscular movement of the total organism. It is impossible to state how far back in the life of the embryo this experience goes. But whenever it begins, it

is probably a diffuse 'feeling of being alive' or 'feeling of activity' not definite enough to be called a feeling of muscular movement, of pressure against the skin, of feeling of body posture, or even of pain.

The first nerve connections between the skin and muscles of the body on the one hand, and the central nervous system on the other, form a single network. A common fiber branches to the muscle and to the skin, so that there is no chance for differential sensitivity. Indeed, the undifferentiated character of the nervous system in its early stages of development makes it imperative to presuppose, as the original contents of mental life, fields or grounds of experience, rather than specific sense impressions.

Emergence of Quality from Ground: Koffka. Koffka has observed that just as local movements emerge from total patterns, so, definite experiences emerge from a pre-existing ground. Most likely the first to differentiate are experiences of hunger or pain, for it is quite evident that the new-born infant is nearly, if not fully, blind and deaf. It is difficult for an adult to imagine what this quality upon a ground is like because the adult's experiences are so well differentiated. It is evident that the hunger is not localized, for the infant's field of experience is not, like the adult's, structured with reference to spatial dimensions and locations. An adult will localize hunger in the stomach-region, and objects seen around him have definite locations in space. But all this is yet to evolve in the mental life of the child. The infant has no idea, at first, of a world about him, and there is no *him;* there is merely a field of undifferentiated feeling with a differentiated experience existing within it, but the hunger comes from nowhere, since for the infant, there is no *place.* The field just exists, and the quality of hunger within it just exists.

Emergence of Figure from Ground. Differentiation of specific experiences develops faster and goes to much greater limits in the realm of vision than in any other sense field. As the optic nerves and brain mature, the general ground of experience takes on a visual cast, perhaps a quality of darkness or brightness. Then from this field, now exhibiting a visual aspect, blurred patches of differing brightness appear, with no

distinct outline. Shortly, distinct figures begin to emerge, standing out upon the undifferentiated ground. Suppose a typical example of such a figure be examined.

One of the first objects which a child learns to recognize is his mother's face. The face is first seen, however, *as a whole. As yet, for the child, there is no eye, no ear, no nose, no mouth, as discrete parts of the face.* The object perceived is a totality *having a field property of its own* that distinguishes the face from other faces, or distinguishes the face at one moment from the same face at another moment. The field property does not reside 'out there' in the face; it is a property of the child's perception, a response to the face as a whole. For convenience the field property may be named 'friendly face' or 'harsh face' as the case may be. This field property is a total 'impression' that cannot be referred to any one part.

The principle here involved may be illustrated in another way. Let an adult enter a room where several people are gathered. Almost at once he knows whether he is welcome, but not because of any specific act upon the part of any individual. *It is possible to sense the atmosphere of the situation all at once.* Such a response as this is like the child's perception of his mother's face in that it is an organized, unified reaction to a total situation. Both are configurational responses.

Whole-Properties of Segregated Parts: Andrews. Long after the child is able to distinguish faces he discovers their parts. Then, curiously enough, *these parts are not recognized if segregated from the face.* Show a child, two or three years of age, the picture of a face and ask him to point to the eyes, ears, nose and mouth. He may do all of this correctly. But now show him an eye, drawn by itself and ask him to identify it. Although it may be an exact duplicate of the eye in the face, *it is no longer an eye. It is a bird's nest, an egg, or some other object. The ear is a coil of rope; the mouth is a stairway; the nose is a tent or a mountain.* Not until the child is a year or two older are the parts of a face recognizable when drawn separately.[4] (See Fig. 24.)

[4] Andrews, Eliz. A., "The Development of Imagination in the Pre-school Child." *Uni. of Iowa Studies,* 1930, Vol. 3, No. 4.

The reasons for these interesting observations are already familiar to us. Parts derive their properties from wholes. Once the child is able to analyze the face into its parts, each part is perceived in relation to the whole; it is an eye, because it is part of a total face; and it is an ear in terms of the face. The face is not the sum of eyes, nose, ears, mouth, cheeks, forehead, chin, for in the development of the perception, *the face comes first and the parts come later.* The same principle is borne out by the fact that differences in color of various parts of the face, in fact differences in the color of faces as wholes, escape the child's notice for several years. A Negro can be distinguished from a white person without noticing any difference in color.

FIG. 24. FIGURE DEMONSTRATING FOR ADULTS THE PRINCIPLE ILLUSTRATED IN ANDREWS' EXPERIMENT.

A, when seen in the face, is an eye; by itself it is a small hat or a teepee. B, when seen in the face, is a nose; by itself it is a broken pair of glasses.

Experiments by Cutsforth. Cutsforth [5] has illustrated the same principle in adult behavior. He cut a hard rubber ball in two and asked blindfolded subjects to identify one of the pieces. Some perceived it as a hardened bath sponge; some as a sponge eraser; but only a few recognized it as half of a hard rubber ball. The toe of a shoe was a small container, or a toy bag, or the end of a shoe-tree. The bowl-part of a spoon was a fishing spinner; the toothed end of a fork was a small comb; a black key from a piano was a polishing stick, or a window prop. The half of a door-knob was a queerly-shaped ash-tray, or the cover of a small metal dish, but not half of a door-knob.

[5] Cutsforth, T. D., *An Analysis of the Relationship Between Tactual and Visual Perceptions.* 1930, University of Kansas. Dissertation.

The Law of Pattern Completion. The observations just made illustrate an organismic law not hitherto encountered, namely, *that when parts are relatively segregated from the wholes to which they belong, they become objects in their own right. They take on whole-properties.* Hence this principle may be called the Law of Pattern Completion.[6] Pattern completion is a common event in nature. It occurred in the two severed parts of a single-celled organism when two new organisms were formed. Each half became a unified whole in the shifting of the physiological gradient. The law of pattern completion, together with the others, heretofore mentioned, is important in understanding how children learn to read and to identify objects in their environment. In fact, it explains how judgment and reasoning develop. It is a principle seen in operation all the way down the animal scale, at least as far as the goldfish. Köhler discovered it in the behavior of apes, when a box, used on previous occasions as something to push under a suspended food-goal, was a box to lie on so long as another ape was using it for that purpose. Perkins found that a light of a given intensity was a food-goal for the fish so long as its properties were derived from a total pattern of lights, differing in intensity, but when a light of the same brightness as the food-goal was presented by itself, away from the whole of which it was a part, it was no longer a goal.

Similar types of behavior can be observed in children. Lois was playing with her doll one day, gently combing its hair, arranging its clothes, washing its face, asking it if it were hungry, or sleepy, or warm. The doll was someone to be treated with tender care, the possessor of feelings, a real human being. Only a few minutes later the doll became an entirely different whole. This time it was something to be explored. Its hair was yanked out; its eyes gouged in, through an effort to ascertain what made them shut; its clothes were ripped off and the dilapidated remains hurled into a corner of the room.

The Problem of Imagery. The problem of perception is bound up with the problem of imagery. After a person has seen a certain object it is possible to remember how it looks. This 'seeing in the mind's eye' is known as visual imagery. If

[6] The same as Wertheimer's and Koffka's law of "closure."

a person were asked, offhand, to tell what states an airplane would traverse in flying directly from Boston to San Francisco, he would probably employ visual imagery of a United States map. It is possible to visualize anything that one has seen, and, under certain conditions, to visualize objects that one has never seen. For example, if an observer were shown for the first time a series of greys ranging through definite brightness-intervals from white to black, with certain of the steps omitted, he could supply the steps with the use of imagery.

Uses of Imagery. Imagery is not confined to visual processes. Melodies are remembered in terms of auditory imagery; tastes and odors are remembered in terms of gustatory and olfactory imagery; pressures, muscular movements, pain, and emotional experiences are remembered in terms of tactual, kinaesthetic and organic imagery. Imagery employed in the recall of specific experiences is known as memory imagery. Images employed in creative thinking have often been called images of imagination, or merely, imagination. When more is perceived in any object or situation than is actually present, the result is an imaginal supplementation of sense experience. Thus, a deer hunter sees a deer and discovers, after shooting, that it was a jackrabbit; a fisherman feels the tug of a fish that turns out to be a snag. The devout spiritualist sees spirits in the amorphous clouds of vapor produced in the séance room by a fraudulent 'medium.' The floor creaks and the nervous housewife is sure that she heard burglars. Exaggerated illusions of this sort are characteristic of insanity, where imagination is mistaken for reality. Then, the experiences are known as hallucinations and delusions. Hearing voices and seeing visions are common occurrences in the delusions of the demented.

Relation of Imagination to Perception. Images have been defined as cortically or centrally aroused sensory experiences, to differentiate them from sensory experiences, proper, which latter, it has long been thought, were dependent exclusively upon the organs of sense. This distinction was supposed to explain the greater stability and vividness of sensory experiences. Now we know that this distinction between imagination and sense perception is arbitrary, and that the one, as

well as the other, involves both the cortex and peripherally aroused processes. True, that a sense perception, such as seeing an orange on the table, hearing a melody on the violin, or looking out over the landscape, is dependent upon stimulation of the sense organs, and is stabilized by the continuation of the stimulus. But the stimulus-situation is by no means the only stabilizing influence. The organization of the nervous system-as-a-whole is quite as important. Imagination is vivid and stable for precisely the same reasons. It is a kind of perception, and differs only in degree from what is ordinarily regarded as perception. The external stimulus-pattern, in case of perception, proper, is more complete and detailed, that is all.

For example, if the orange were seen in a dim light it might be perceived as a ball of yarn or a pin-cushion. The stimulus-pattern is incomplete, but the imagined object is as stable as the stimulus-pattern permits. Again, when one hunter mistakes a rabbit for a deer and another sees the object as a rabbit, the difference lies in the organization of the two responses. The light rays fell upon the retinas of the two men in very much the same fashion, producing very much the same reflected images. What, then, accounts for the difference between the two experiences? The difference depends upon two different grounds, or cortical organizations, from which the two perceptual processes emerged at the time. One man was looking for a deer and his perceptual processes were organized toward that end. The other was organized for any particular object that might appear. These examples show how perception and imagination are two aspects of the same whole.

Imagination in Children. The problem of children's imagination is of vital importance in Educational Psychology. Imagination is prominent in play activities. *Inexpensive, crude and poorly executed toys and pictures are just as good, and often better, than expensive ones.* Moreover, when children first become interested in objects, even in pictures, it makes no difference whether they are held upside down or rightside up. All this is because the child's perceptual space-frame has not yet differentiated, and imagination functions at this level as readily as at any later time.

Children play and talk with imaginary companions and

parents. Sometimes these companions stay with them for long periods of time, especially if there is lonesomeness or unhappiness in the home. The exaggerated stories that children tell concerning the objects they observe and the activities in which they have engaged show that their entire field of experience is undifferentiated. The distinction between real and imaginary situations made by normal adults has not yet been adequately discovered. The appeal of fairy stories, legends, and adventure is, in part, dependent upon undifferentiated judgment. All of these facts demonstrate the importance of an imagination that has not become separated from perception.

When children become adults, they often lose the imaginative aspects of their mental life in favor of the utilitarian and practical. As a consequence they lack an appreciation of art, music, literature and philosophy, for all creative processes like these are products of imagination and require imagination if they are to be understood. Many adults permit their field of experience to differentiate too far in the direction of specialized activities having only to do with the 'material' world around them. Then their mental life suffers in various subtle ways through a lack of interest in things less tangible but extremely vital for adequate living. They become unable to appreciate situations that must be perceived unanalytically, with feeling and imagination. Our educational system is pathetically meager in those methods that preserve the imagination, and therefore the inventive aspect of mental life.

Imagination is important, also, in children of maladjusted personalities. When the world around the child does not permit the resolution of tensions without the expenditure of too much energy, he will become introverted. He resorts to the easier method of daydreaming in resolving his tensions. Daydreams are normal and important but, like all other forms of behavior, become dangerous when exaggerated. Cases described by Wheeler and Goddard illustrate what happens in cases of excessive daydreaming that eventually end in secluded or dissociated personalities.[7]

[7] *Cf.* Wheeler, R. H., *Readings in Psychology.* New York: Crowell, 1930, Readings IX and X.

The Rôle of Imagination in the Perception of Wholes and Parts. Why is a child unable at one period in his mental development to recognize parts removed from the wholes to which they belong, while subsequently he recognizes the parts as belonging to some whole? At about the age of three, when the child is able to identify an eye within a face, but not away from it, he is unable to imagine a face in connection with any outside object, after the picture has been removed. The segregated eye, therefore, is not seen at the same time the face is visualized. As a consequence the eye becomes another object. Recall again the experiments by Köhler on apes, when a stick was used as a tool with which to drag in a banana, so long as the stick and the banana could be seen at the same time. But when the stick was at the other side of the cage, seen when the ape's back was turned upon the banana, the stick was not a tool with which to secure food. It was an implement to use in pounding the bars of the cage, or something to manipulate. The ape lacked the imagination necessary to apprehend as a tool the stick across the cage. The stick at that time possessed a different property.

How, then, does the child learn that an eye is an eye, anywhere? Note that originally the eye emerged from the total pattern, 'face,' and derived its property of being an eye from the face-as-a-whole. Before it can be perceived by itself as an eye, its property of *eye-ness* must emerge still farther and the total face-pattern must diminish in prominence as the whole that guarantees the meaning of the part. Some whole, of which the eye is a part, must, however, always be present to the child, if the eye is to be recognized. Later on the perception of an eye need not involve perceiving an actual face. The remembrance of the face, or in other words, imagery of it, suffices.

At this point a warning is necessary. If the segregated object is seen as an eye, the perception of the eye does not come first and the image of the face later. *The child's imagination is an essential aspect of the perception itself* and it is the imagined face in terms of which the eye is perceived. The perception is the *total experience* which analysis breaks down into imagery *and* sensory processes having to do with the eye.

From this discussion it can be concluded that the correct

recognition of an isolated eye comes when, with the aid of imagination, a field of experience, larger and broader than the mere perception of a face, evolves through expansion and differentiation. This larger field is the whole of which the eye is now a part, hence the eye can be recognized away from the face.

The Expanding Perceptual Pattern. The expansion process goes on still further, however. Eyes are being observed as parts of larger and larger total situations. This comes about through maturation. Eyes are perceived not only as parts of a face but of a whole human being; not only of a whole human being, but of a social situation, for all human beings have eyes. Eyes are observed as parts of animals, dolls, pictures, statues. But this is not all. The *word* 'eye' has been learned. Now the whole of which eyes are parts is a tremendously expanded total situation, involving the meaning of the word 'eye.' Thus it comes about that visual imagery of a concrete face from which a segregated eye must derive its property of 'being an eye' is no longer necessary. The eye is now a part of a vast total ground of experience, a ground that is not now merely a concrete face. It is a concept, a general idea, carried with the aid of a word. By this time, when a segregated eye is seen, its property is derived from a concept, a thought process whose meaning is abstract. The child *thinks* 'eye' as he sees it. The concept (like the concrete imagination in the earlier case) and the perception are, once more, the unified, total experience of the moment broken down into its parts. The stimulus, eye, initiates the whole experience as one configuration.

When the practical problems of teaching reading, spelling, arithmetic, and other subjects are taken up, these facts will be expanded into important principles, the *law of transposition* and the *law of segregation.*

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CHAPTER VIII

PERCEPTION AND THINKING IN THE CHILD

The Problem of Perception

An Approach to the Problem of Perception: Wheeler and Cutsforth on Synaesthesia. So far, mental development in the child has been traced through the emergence of quality and figure from a ground, and the development of the figure has been traced to the growth of concepts or general meanings of total situations. That perceptions of objects come about through the expansion and differentiation of an experience-pattern, just as local movements of the body come about through the expansion and differentiation of a movement-pattern, can be demonstrated in still another way.

There is a phenomenon, common in the mental life of children, known as *synaesthesia.* Literally, synaesthesia means 'a sensing together,' for example, seeing colors when tones are heard. This particular form of synaesthesia is called colored hearing. There are many other kinds such as experiencing tastes when sounds are heard, but colored hearing is the most common variety.

Persons who do not hear tones in this way are prone to suppose that the synaesthetic individual is merely linking a superfluous color with the tone, through association, and that the color is an imaginal luxury. But such is not the case. If the *synaesthetic individual does not see the color he fails to hear the tone! The color is an essential process of his hearing.* At first thought, this appears rather amazing. Nevertheless, all people hear in essentially the same way. Listen to any tone, describe it, and note the adjectives employed. The tone is round, smooth, rough, bright, dull, mellow, full, thin. A tone might just as well be red as round, blue as smooth, yellow as full, green as mellow! None of these, as isolated terms, are,

any more than colors, relevant to sound. Then why are such terms employed? For exactly the same reason that colors are employed. The tone is actually experienced as round or smooth, or mellow, or full, by most people, and actually experienced as colored by others. Hearing a tone, therefore, is more than sensing a sound vibration. Audition involves more than the one sense modality. If the tone were to be described completely, most if not all the other sense departments would be involved. Strictly speaking, there is no process such as a simple sensation. Qualities of experience popularly known as sensations: tones, experiences of pressure, warm, cold, pain, taste, smell and even colors themselves, are configurations, like the perception of a face.

Physiological Processes Involved in Perception. This situation is not so surprising when we reflect that the organism responds as a whole even to so-called isolated stimulations impinging separately upon the nervous system through the eye, ear, and other organs of sense. *The ear is a necessary but not sufficient condition for hearing.* The ear, alone, does not determine what the nature of the auditory experience will be. A field of experience and a total nervous system are also necessary. Not only that, but the quality that emerges from a ground *must be a complex pattern, to exist at all;* it must have a field property of its own. Unless, within itself, it was differentiated, and, therefore complex, it would have no field property.

Physiological facts substantiating the conclusion that a field of consciousness is involved in the emergence of a specific sense experience have already been pointed out. Recall Lashley's work on the functioning of the cortex in animals, and the preliminary studies of Bartley, Newman and Perkins on the cortex, by the method of amplifying action currents. Since the total cortical field is more or less differentiated, one would expect that hearing a tone would be a complex process, not alone auditory in character, but visual, tactual and kinaesthetic as well. Ordinarily these fine details of the perception are not analyzed psychologically, for the listener hears the tone as a whole, and recognizes only its field property, which is the audi-

tory meaning, tone. (See Fig. 25 for a diagrammatic representation of differentiation.)

Returning, now, to the specific problem of synaesthesia, the presence of color in the process of hearing can be understood. When the child first receives an auditory stimulus, visual, auditory, tactual and kinaesthetic qualities of experience have not individuated with respect to their specific modes of sensory stimulation. He hears, in a relatively undifferentiated way, with all his so-called senses. In the case of colored hearing, there is no distinction possible between auditory aspects of the experience and those of color, brightness, and feeling, because the two have not, and never will, differentiate. But in all cases, individuation never results in absolute segregation; pure sensations never emerge, even in those who do not have colored hearing. Hence, for them, too, hearing is never a pure auditory experience; pressure is never pure pressure; pain is never pure pain. It turns out, therefore, that in mental life there are no discrete sense departments. There are specialized organs of sense, the retina, the cochlea (inner ear), end-organs in the skin and muscles; but they are specific anatomically, not functionally.

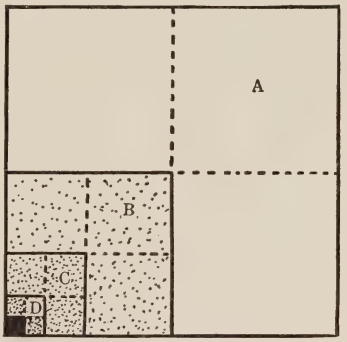

FIG. 25. DIAGRAM TO ILLUSTRATE THE PRINCIPLE OF DIFFERENTIATION.

A represents an undifferentiated field or pattern. The stippled square, B, one-fourth of the area, A, represents a certain degree of differentiation, but it is still part of the area, A. In turn, C and D represent further degrees of differentiation of A, through B. E represents a final stage in the differentiation process; it is part of D, but also part of C and B, and still is a part of the original area, A. Similarly a finger movement is a differentiation of a total body movement, with hand, arm and trunk corresponding to D, C and B.

A recognition of these important facts would go far toward a better understanding of the child. His world of experience is at first relatively undifferentiated and, although orderly enough from his standpoint, seems confused to an adult. Consequently, it is a mistake for an adult to read his own world into

that of the child. Frequently, strong likes and dislikes pertaining to sound, taste, smell, color and other sense objects, are formed by children when their experiences are quite unlike those of an adult in similar situations, and therefore incomprehensible to the adult. Moreover, difficulties which children encounter in discriminating sounds, colors, tastes, and tactual qualities, often attributed to dullness or stubbornness, are merely matters of undifferentiated response. It is not uncommon to find children disputing over the nature of things seen, felt and heard. This is not due to faulty development of sense discrimination but to divergent lines of differentiation conditioned by different types of stimulus-patterns.

Importance of Discovery in Perception. *Every perception involves actually or potentially an inventive aspect.* This, of course, is but another way of looking at the process of expansion and differentiation in the total behavior-pattern. The inventive aspect of perception is akin to the appearance of new motor co-ordinations observed when the total behavior-pattern is regarded from the standpoint of motor activity. It is imperative, if the real character of behavior in the child is to be understood, not to think of perceiving, thinking, and motor coordination *as separate things. Each response of the child reveals all of these aspects.* This is why discovery can be observed no matter from what standpoint a given act of behavior is studied.

Wanting something that has never been wanted before, making a movement that has never been made before, perceiving something that has never been perceived before, having an idea that has never occurred to the individual before, are all consequences of maturation. In the adult this appearance of new responses is called invention. The creative activities of the novelist, artist, sculptor, and scientist are of the same order, no different in basic character from the discoveries a child is constantly making.

It is important too, to realize that even such simple activities as observing objects in one's environment, executing new movements as in learning to write, executing a simple task never before carried out, such as running an errand, learning to spell, to add and divide, are all *inventions* from the stand-

point of the child. They should be accomplished in the same spirit that a research enthusiast makes a discovery, or an explorer finds a new world, or an artist creates a painting. *Indeed, the thrill is the same.* But how often these simple achievements on the part of the child are curbed by formal demands, by drill and bribes that sap from his behavior its quality of inventiveness *by preventing the goal from being its own reward.* Dry, cold, indifferent methods of instruction in the hands of teachers who are merely going through a routine in the effort to eke out a living, soon deprive the child's behavior of its inventive aspect. As a consequence, his whole behavior suffers: personality, intelligence, interest, vigor. The child vegetates in proportion to the loss of the adventurous aspect that is the life of mental development. Unfortunately, much damage is also done in the home by parents who are too busy to play with their children, and to participate in the child's adventures. Learning is the conquering of new worlds and unless done in that spirit it is not useful, thorough, or permanent.

Development of Space Perception. Perception involves orientation to a world of space. The story of how children learn to orient themselves in a world of three dimensions is long and complicated. Only a bare outline can be presented here. First, the infant's awareness of space is general and undifferentiated, having to do merely with its extendedness or expansiveness. At the outset it is a space-frame, having no up or down, no right or left, no breadth *versus* depth. Objects within the field have no recognized position. All the intricate space relations perceived by the adult when he sees an object on the mantel, must be discovered by the child in the course of maturation. Exploration and manipulation play an important part in furnishing the necessary stimulation.

Knowledge of right and left, up and down, here and there, specific size, form and location of objects, distance of objects from the child, and the movements of objects, all come about by expansion and individuation processes going on within this space-frame. The only way space relations can be learned is by proceeding from the whole to its parts. The position occupied by any given object, say a table in the room, is always perceived

in its relation to the room as a whole. There is no position until there is a field in which to have a position.

Thus, when the infant extends his arm toward objects that are beyond reach, even toward the moon, it is because his world of space is not differentiated to the extent that objects stand out in their relation to the total field. The undifferentiated character of the infant's early space perceptions is again illustrated in his inability to see rapidly moving objects. Toss a ball in the air and he will not follow it; roll the ball rapidly across the floor and he will not see it. The perception of movement requires a highly differentiated space-field because *each momentary position* of the object must be perceived in relation to the total field. The nervous system must reach a high degree of specialization before this fine discrimination between different positions in the field can be made. This is why it is dangerous for a young child to be alone on the street. His perception of an approaching automobile is poor; he cannot adequately judge its speed or its distance from him. Not knowing the moment when, to avert injury, he must dodge, he fails to realize the danger of the situation.

Experiments of Gelb and Goldstein. Experiments by Gelb and Goldstein [1] add light to the general problem of space perception. It has long been supposed that space can be perceived separately through certain of the sense modalities, especially those of vision, hearing, touch, and kinaesthesis. But Gelb and Goldstein discovered that a patient, deprived both of the perceptual and imaginal aspects of vision by a brain injury, was not able to tell, when touched on the body, where the stimulus had been applied. Let a normal individual, blindfolded, be touched upon the back of the hand and he localizes the contact at once. The tactual experience stands out upon a ground whose spatial aspect is visual. Since without this ground the touch is not localized, it is evident that spatially organized tactual experiences will not emerge from a tactual ground.

The same facts evidently hold for the localization of sound, for sounds, too, are heard as coming from a certain direction

[1] Gelb, A., and Goldstein, K., "Psychologische Analysen hirnpathologischer Fälle auf Grund von Untersuchungen Hirnverletzter, VII." *Arch. f. Ophth.*, 1922, Vol. 109, 387-403.

and from a certain distance, because of their emergence from a visual ground. There are other factors, of course, involved in listening to sounds, such as muscular movement. It is difficult to localize a sound coming from a plane midway between the two ears. When a sound comes from the right or the left of the median plane, the observer ordinarily turns in the direction of the sound, or muscular tensions arise in the direction of the sound. Similarly, when one is touched on some part of the body, incipient movements of the eyes, head, or hands occur in the direction of the contact. But the perception of the contact or of the sound itself involves visual as well as kinaesthetic processes. This again demonstrates the synaesthetic character of perception. As in the case of colored hearing, the localized pressures and auditory experiences exhibit of themselves a visual aspect which places the experience definitely in a space-frame and gives to it localization.

Relationships Between the Senses

Cutsforth's Experiments: Interdependence of the Senses. Experimenting on the interdependence of sight and touch, T. D. Cutsforth [2] presented to large numbers of blindfolded observers various plaster figures raised in relief, some simple and some complex, with instructions to identify them. No amount of tactual exploration resulted in accurate recognition. In fact, the figures appeared to be sheer nonsense, as perceived through touch, and meant something to the observer only in terms of visual imagination. Tactual experiences themselves did not become complete figures; they lacked unity and organization. The figures were constructed visually. With meager cues obtained through touch, some of the observers in this way guessed the objects correctly but the majority were greatly surprised when, allowed to see the figures, they beheld almost perfect representations of a fish, man and frog. Cutsforth's experiment substantiates the results of Gelb and Goldstein and points to the conclusion that space is never perceived through touch, alone.

[2] T. D. Cutsforth, *op. cit.*

Application of This Principle. *The results just discussed show that the sense organs always function in a mutually dependent fashion.* Each perception of a single stimulus involves a response of the total organism. The same principle was discovered by aviators in blind flying, as in a fog or dense cloud. Spatial orientation with respect to the earth cannot be perceived through the sense of equilibrium. A certain pilot of several years' experience entered a storm area which he thought was only local and could be navigated with safety. But when he had penetrated two or three miles the clouds became so dense that he retraced his path. As far as he knew, he turned just as he always had done. Imagine his surprise when, upon reaching the edge of the storm, *he looked down and saw the sky.* The perception of bodily position with respect to the earth was incomplete in the absence of a visual space-frame, in spite of normal organs of equilibrium located in the internal ear. Inexperienced flyers must always rely upon the horizon to maintain this space-frame. Blind flying is almost always fatal without an instrument on the panel to inform the pilot when the plane is right side up. Even then, when the panel indicates that the plane is bottom side up, it is difficult to apprehend *which direction is bottom side up.* The visual space-frame within which right side up and up side down are differentiated (with the earth invisible) must be maintained through visual imagination, with a bubble on the panel instrument the only cue.

Educational Significance of Sense Interdependence. In the education of the blind, especially of the congenitally blind, a recognition of these facts is important. Lacking a differentiated visual space-frame the congenitally blind have a very different idea of objects, indeed, of the whole world about them, than seeing persons. They cannot hear sounds as seeing individuals do, localize and organize their touch experiences as seeing persons do, or guide themselves around as others do. The character of their space-world is, as yet, almost a mystery. We know, however, that efforts of the blind to learn about objects around them are greatly handicapped, at present, by methods of instruction based upon the erroneous belief that space perception comes through touch alone, or through a combination of touch and muscular movement.

In the education of seeing children, this principle is still of importance. Because objects are presented to one of the so-called senses, say hearing, is no guarantee that the child's awareness of the object will involve only auditory processes. The meaning of the object will not be apprehended until it is perceived in the light of a total situation *with the aid of other senses.* It is quite probable that monotones, for example, are children unable to hear a particular tone in relation to the entire range of tones. The process of hearing tones *on pitch* must emerge from an undifferentiated preliminary grasp of an entire tonal range. A space-frame of some sort is essential for an apprehension of the range, for range implies extendedness. Then the range, having extent, will differentiate into individuated perceptions of tones having this or that pitch. In seeing individuals this space-frame is to some extent, at least, visual, for pitches are described as *high,* or *low.* The monotone is one who has failed to grasp the significance of range, perhaps to 'see' it, before he attempts to judge the pitch of individual tones. By a judicious training in which a monotone learns ranges of tones first, he can be taught to identify pitch correctly and to sing on pitch.

Perception of Movement

Visual Perception of Movement: Wertheimer. An investigation into the visual perception of movement is of considerable aid to an understanding of mental life in general. Here the conditions that prove the configurational character of mental activity can be easily detected and controlled. In fact, the configurational character of mental activity was first experimentally demonstrated by Wertheimer in 1912 in a study of 'apparent' movement.[3]

Suppose two vertical, parallel slits, one-eighth inch wide, an inch long and about an inch apart are cut in a cardboard screen. An apparatus is constructed behind the screen that will throw light of the right intensity through one of the slits for an instant only; then, after the proper time interval, through the

[3] Wertheimer, M., "Experimentelle Studien über das Sehen von Bewegung." *Zeit. f. Psy.,* 1912, Vol. 61, 161-265.

other. The experiment is performed in a dark room. If the conditions just indicated are under proper control, the observer sees neither slit, but merely a flash of light moving from the position of the first slit to the position of the second. There is something very curious about this experience. Note that two separate bands on the retina, corresponding to the two slits, must have been stimulated. The retina between the bands, the space that corresponds to the distance between the slits, received no stimulation. Yet the only light seen was a flash between the slits. There was no retinal stimulation corresponding to this flash. Nevertheless, the movement was not an illusion; it was real. If, under the right conditions, a slit, with the light shining through it, was moved across the retina, the observer could not tell the difference between this movement and the one previously described.

Perception of Real Movement. If one inspects the retina with a miscroscope, he sees that it is composed of rod- and cone-like cells, packed closely together, yet, with actual spaces between them. When a moving light crosses the retina, therefore, there exists a situation quite comparable to the two slits. Rods and cones in one band are stimulated, and a very small fraction of a second later, rods and cones in another band are stimulated. *The stimulation is actually discontinuous, just as in case of the two slits.* The explanation for the two movements, 'apparent' and real, must be the same. Of course, in the slit experiment, if the stimuli are too far apart, or the interval of time between the two stimulations is too long, first one slit of light will be seen and then the other, or the two slits will flicker. If the distance between the slits is too short, or the interval too brief between stimulations, both slits will be seen simultaneously.

Explanation of Visual Movement. The explanation of visual movement is suggested by the consequence of having the light that is flashed through the first slit of weaker intensity than the light that is flashed through the second. Under these conditions movement is seen going 'backwards,' that is, from the second slit back to the first, just the opposite of the order in which the stimuli have actually been presented. This proves the configurational character of the perception. *Nothing at*

all is seen until the second exposure is given. Then the perception occurs as a response to the *completed* stimulus-pattern, which is a total situation. *From the standpoint of dynamics, the perception of movement does not arise until the condition for the end of the movement is guaranteed by the same stimulus-pattern that conditioned the beginning of the movement.* The movement represents adjustments in the brain from high to low potentials in the line of least action. The high and low are at once conditioned by the total stimulus-pattern.

Higher Thought Processes of the Child

The World of the Child When Confined to Perception. What would a child's world be like if confined to perception? An answer to this question will aid materially in understanding the psychological importance of mental development beyond the level of perception. Show to a three-year-old child a picture composed of a kitchen scene, and ask him to describe it. He will see a chair, a table, a cat, a woman, a window. Each is a relatively segregated object, except for its size and space relations, standing out upon a ground. The ground is the picture as a whole. Like the leg reflexes in Coghill's salamanders, these perceptions, once emerged, remain so. They will summate to constitute a perception of the picture no more than the reflexes would summate to constitute walking. The observational world of the child, at about this stage, is a world of discrete objects. He cannot see the cat, then the woman, then the table, and construct a related scene or story *from* these parts. He must wait upon further maturation when the objects will emerge in their logical relations.

The perception of single objects was precisely what occurred earlier in the life of the child, in looking at his mother's face; but complicated situations like a picture with many objects, or a display of objects in a shop window, are too intricate in detail to be grasped all at once. Consequently, the child sees what he can and ignores the rest. What he sees and understands is figure; the rest is ground. An adult perceives objects in a similar fashion when confronted with problems that are too difficult, such as a mechanical puzzle. Failing to see the

total situation, he notices only the parts. Failure to apprehend the puzzle as a whole means failure to detect the principle involved.

When the child matures sufficiently to grasp larger and more complicated situations in their totality, objects then emerge in patterns of knowledge differentiated with respect to their logical inter-relationships. Now, when at the age of five or six, show the child the same picture as before. It is a different picture; *the cat is lying on the floor, in front of the table, and the woman is getting the cat something to eat.*

Judging. When objects emerge from total perceptual patterns so that the apprehension of concrete relations between the parts is involved, the process is known as judging. The child is able to tell that this object is different from that, smaller, larger, longer, shorter, hotter, colder, higher, lower; or, that one object is doing something to another.

There are three important principles to remember about judgment. First, the direction of *the total process must be guaranteed before the process commences.* The guarantee comes in the apprehension of the problem, or in a consciousness of the task. Consciousness of the task represents the dynamic whole which is to condition the beginning, the entire course, and the end of the process. Second, just as the fall of the apple is conditioned in time and space by a gravitational system, so the process of judging is conditioned in time and space by a field of knowledge. Hence the judgment is a unit from beginning to end. This is proved by the fact that the apprehension of the task involves an anticipation of the *end* as well as an awareness of the *beginning* of the performance. And third, judgment is a dynamic process whose beginning is the setting up of a tension and whose end is a resolution of that tension in solving a problem. It is a configurational response, organized with respect to a total situation.

Inventive Aspect of Judging. Just as perception always involves an inventive aspect, judgments are processes of invention. Each relation is a discovery. A vast new world opens up to the child when he discovers that objects and situations actually *differ from one another.* Again the discoveries of these differences should always be made in the spirit of adven-

ture and of creative work. *They are so made when the child is left to his own devices!* They should be equally so when the child is learning in school.

Much grief could be spared children when demands are made upon them, by ascertaining, before they try to execute a task, if their comprehension of it is sufficiently definite to guarantee completion. Often the reason why children do not obey instructions is their lack of understanding, not their uncooperativeness. Discipline under such conditions can only injure the *rapport* between the child and the person who gives the instructions. Moreover, reproof may also play its undesirable rôle in promoting the feeling, on the part of the child, that he is less capable than he really is.

In so complicated a process as judging, many circumstances may interfere with its course. A falling apple may not reach the ground directly; it may hit a branch and bounce to one side, or land on a roof. Then its course is irregular, but no matter how devious the route, a system of energy, including a remote end, is conditioning the apple's performance. On no other basis would the apple, no matter how many the bounces, ever approach nearer to the earth *with each bounce.* Distractions may interfere with a child's process of judging; the objects to be compared may be difficult to handle, but each effort should bring him nearer the goal of solution. When the process thus meets with resistance, the child will give up unless the original tension is sufficiently strong to insure completion against the resistance. A tension sufficiently great may mean special interest in what he is doing, a strong desire to please the parent or teacher, but strength does not mean sheer energy; it also means organization of that energy, in this case, insight into the task.

The Development of Abstract Thinking. We must now follow the child through another step in the expansion and differentiation process that we call intellectual development. Our cue will be obtained from the child's use of the same word in naming different situations. A young girl was walking with her mother one day, and, as they stepped upon a bridge, over a millrace, her mother allowed her to throw sticks and stones into the water to see the splash, telling her that she was standing over the 'millrace.' Not long thereafter they were riding in a

train on their way to the beach, and passed over a high bridge, above a river. The child, looking down to the water, said, "Mother, look at the millrace." And when they finally stood upon the beach, the child looked out over the ocean, danced up and down with glee, and shouted, "Oh, Mother, look at the big, big millrace." Here, then, is the next step. The child implicitly notes similarities between situations and gives them the same name.

Children's thinking is not confused; it is undifferentiated. It is evidence of a certain kind of *precision* that, subsequently, will reveal itself in reasoning. It means again that the field of experience from which the child's recognitions of specific objects are emergents, is general in the beginning. Here general means undifferentiated; nevertheless, it is an accurate perception of total situations. A statue, doll's photograph, a person, are perceived as wholes by the child, and the wholes are so undifferentiated that differences between them are not noticed. They are, therefore, all given the same name. But the total situation is perceived with precision and never confused with other total situations. We have seen that one of the first predictions that can be made about an infant's perception relates to the *certainty* with which he can distinguish his mother's face from any other without realizing the existence of eye, nose, mouth, and ears. Likewise, the child can understand a millrace-river-ocean situation in its totality without realizing the differences between the objects.

Formation of Concepts. Differences between objects are meanwhile emerging, however, and playing a dominant rôle in the child's understanding of things around him. He is able to recognize differences between objects sooner than he is able to recognize similarities. The latter process must wait upon further maturation, which appears from the eighth or ninth year on. The field of experience which, in the earlier years of life is general in being undifferentiated, with no explicit recognition of general features, expands to much larger proportions. The patterns of experience that now emerge from this field are perceptions of vast total situations, the parts of which are all interrelated, as they emerge, in terms of explicit knowledge of the properties of wholes. The properties have taken on whole-

character in their own right, and can be employed, deliberately, in processes of thinking. This process is called 'generalizing abstraction,' or the formation of concepts. It involves the explicit recognition of aspects in common between all the parts of a complex situation.

Expressed in words the difference between a judgment and a concept is this: A judgment is equivalent to saying, "*This* ice is cold," a statement that implies having compared a piece of ice with something less cold. A concept is equivalent to saying, "*All* ice is cold," and implies the discovery of a property common to all pieces of ice. Rules, principles, definitions, axioms and scientific laws are all examples of concepts. Judgments, then, are recognitions of concrete relations between specific objects while concepts are recognitions of abstract relations.

An Illustration of Reasoning. Let us ascertain how this works out in a special case. Show John, 10 or 12 years old, a piece of paper and instruct him to watch carefully. Fold the paper once, tear a small hole in the middle of the edge along the fold, and ask him how many holes there will be when the paper is unfolded. He will probably give the correct answer, one. Now take another sheet, and fold it over once, then again at right angles to the first fold. Tear a hole along the single folded edge and ask him how many holes there will be in the paper. Perhaps this time he will give the correct answer, two. With a fresh sheet, fold the paper three times and note the response. If he answers three, a hole for each fold, he is wrong; there are four. Show him the paper, unfolded. Then try again, this time folding the paper four times. If he gives the correct answer, eight, it is almost certain that he has apprehended the principle, and doubly so, if, with five foldings, he answers sixteen.

Inventive Character of Reasoning. What is the psychology of his procedure? As in forming a concrete judgment, John must commence with the apprehension of the problem. He is to tell, each time, how many holes there are. This total pattern of experience represents a tension that demands resolution toward a remote end, the solution. The function of subsequent stimulation presented him in the course of repeated questioning and in showing him the folded sheets of paper, *is*

that of bringing about an expansion and differentiation of this total pattern, and the expansion and differentiation must occur in a way that resolves the tension. He sees the first sheet with one hole in it; then the second with two holes, and the third with four. If he is to make a correct response, it must be guaranteed by some whole, but in this case the whole was not all in existence at the beginning of the experiment; a subordinate whole must function under the government of the less differentiated one 'to tell how many holes there are each time.' This subordinate pattern of experience must emerge in response to seeing the three sets of holes, 1, 2, and 4 (or four sets, 1, 2, 4, and 8). John looks at the array of holes. There is formed, then and there, the subordinate pattern expressible in the words, 'the holes double in number each time.'

Assume that John had not discovered the relationship of doubling before. He must discover it sometime. The total situation must be perceived first as a property running through the entire set of numbers; then each number takes on a new property, derived from this whole, a property which, for him, it had never possessed before. 2 takes on the property of 'being the double of 1,' 4 the property of 'being the double of 2,' and 8 the property of 'being the double of 4.' More than this, each number takes on, from this whole, the property of being in a given place in the series: 2 after 1, 4 after 2, 8 after 4.

Now we come to the crucial characteristic of this type of whole, a meaning so general that it is universal. It is a whole that determines the selection of the next number, 16, and the next, 32, and the next, 64, and so on, *ad infinitum. Thus, the comprehension of abstract wholes leads to anticipations into the future, and to predictions. A type of perceptual whole has emerged that conditions an indefinite number of parts.* The resolution of the tension has involved the emergence of a subordinate whole that constituted a discovery. It was the emergence of insight into a new, total situation, not met before.

Inadequacy of the Experience Theory. Once more a warning is timely. Why was this whole not built up from its parts by experience? In the first place it could not have been so constituted, for these experiences were new to John. He had never thought before that 2 was the double of 1, 4 the

double of 2, and 8 the double of 4. Moreover, there are no experiences in existence that will summate or combine to make up the relation of 'double.' Add 2 and 2 and the answer is 4, but '2 plus 2' does not contain the idea of doubling; it contains only the idea of adding. Multiply 2 times 2 and obtain 4; again this does not contain the idea of doubling, only the idea of multiplying. There is nothing whatever in John's previous experiences with numbers that gives him the idea of doubling. Consequently, this is a relationship that must be *discovered* through an expanding and differentiating experience, forming a new whole. John has *discovered* a total number-situation that gives to specific numbers, properties they never possessed before. The discovery is the outcome of a growth process, just as making a new movement is the consequence of maturation.

In spite of the fact that the development of a concept involves making a discovery transcending previous experience, each stage in the process is conditioned in part by a pre-existing whole which, before the process starts, guarantees the solution in terms of the stimulus-pattern. John would not have made the discovery had he not been under tension toward a goal; his train of thought would not have taken an orderly course had his thoughts not emerged from an undifferentiated comprehension of the task, or would the numbers have been perceived in their proper relations had he not grasped the situation as a whole. Each step in the process, initiated by successive stimuli, the sheets of paper with the holes, was an emergence from his grasp of the total situation. *The steps were already organized as they occurred.* John may have hesitated and made wrong responses with respect to false suggestions and distracting stimuli, but his performance was a unit from beginning to end, not composed of parts. It was a grasp of the total number-situation from which emerged successive perceptions of the numbers 1, 2, 4, and 8, with new properties.

Reasoning resembles apparent movement. The relation of 1 hole to the first folding, 2 to the second, and 4 to the third, was not perceived, in each case, until the stimulus-pattern was complete enough to arouse a unified response to a total situation. Thus, the grasping of a principle or plan is a relation apprehended between a first stimulus and a last one, but not *until*

the last is presented. It is only then that the first stimulus has its observable effect.

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CHAPTER IX

THE SOURCE OF INTELLIGENT BEHAVIOR

The Nature-Nurture Problem

Nature of Inheritance. Factors having to do with inheritance are passed on from parents to offspring through the germ plasm of the parents. The male contributes his share through one miscroscopic cell known as a spermatozoön which reaches the egg and fertilizes it. The fertilization process is essentially an 'interaction' of the vital centers of the spermatozoön and the egg. Each of these centers, or nuclei, contains bodies known as *chromosomes* in which 'factors' or 'genes' are arranged in series. The genes are supposed to be large organic 'molecules.' The fertilized cell receives half of its total number of chromosomes from the male and half from the female. Then the fertilized cell begins at once to grow and divide; the divisions continue, eventually forming the countless numbers of cells of which, anatomically, the body is composed.

Each of the body cells contains descendants or representatives of every chromosome present in the first cell of the new organism. Groups of genes within the chromosomes determine, as far as inheritance does determine, the character of various parts of the body. Genes, however, *are not independent determinants of inheritance.* The contribution that one of them makes to the organism depends upon the contribution that all the other genes are making. *Moreover, whether it shall make any contribution or not depends upon the field properties of the organic mass into which the cells are growing.* For example, there are genes in the early cells of the embryo on which the development of an eye will depend. Suppose these cells are in the head end of the embryo. If this tissue is taken early enough and exchanged for tissue at the tail-end of the embryo, no eyes will develop there. The tissue from the tail-end will

supply the eyes, for at this stage of the embryo's development, the cells will be able to grow into a great variety of organs. They have the genes that are necessary for many alternative types of tissue. Thus it can be seen that whether the potentialities of the genes will be realized in growth or not, depends upon the environment, within the growing organism, in which the cells develop. Genes follow the law of configuration.

Experiments show that at an early stage, the organism can be subjected to abnormal pressures, irritation, chemical or electrical treatment, and monstrosities produced. For example, two heads can be made to grow, or the cells all made to grow into heads and nothing else.

Limitations of Inheritance. For a long time it has been the popular conception that physical and mental traits were exclusively a product of heredity. The view still prevails that 'heredity is fixed, nothing can possibly be added to it,' a conception as harmful as it is untrue. Recent studies in genetics lead to the conclusion that, whereas the character of the organism is in part determined by the genes, all of the characteristics of the organism could, if the means were known, be altered within limits by changing the environmental conditions under which the organism develops. Also, similar changes could be produced by altering the genes. There is evidently no change that can be induced by altering the germ plasm and keeping environment constant, that cannot, theoretically, be induced by keeping the germ plasm constant and altering the environment of the growing tissue.

Of course common observation, and experimental breeding in plants and animals, point indisputably to the fact that the species or race ordinarily has under its control many characteristics of any organism in question. The offspring from mice are not rabbits, nor is an Indian obtained from pure-blooded Irishmen. The important thing to remember, however, is that the original, undifferentiated cells of the embryo contain all the genes that permit the multiplication and differentiation of these cells into different kinds of organs such as muscles, eyes, stomachs and glands. Other factors than those coming from inheritance determine which of these patterns of genes shall express its growth potential in the actual development of an

organ, and *where in the body the organ will develop. Inheritance does not account for unity and organization in the developing organism.* These, as Chapter VII brought out, are conditioned by environment and by the physiological gradients which are field properties of the organism-as-a-whole.

Thus, what a certain cell may lead to depends not merely upon its hereditary constitution but, first, upon its relation to its immediate surroundings in the organism, and, second, upon external environment. Similar sets of genes in different cells produce different tissues, that is, follow a different course of action, under different systems of physiological stress within the organism. *The organism-as-a-whole, then, dominates cell formation,* massing its material and shaping its organs as if cells, as such, did not exist, or at least, as if they existed in complete subordination. Development, therefore, is not primarily the establishment of an association, or a multiplying of elementary units to form a new individual; instead, it is the resolution of one whole into newly formed parts; it should be thought of, not as a multiplication and co-operation of cells, but rather as a differentiation of protoplasm.[1]

The Relativity of Inheritance. We must think of inheritance as *only one* cause of growth. Nothing preventing, the growth potential provided by heredity will be realized in a development that resembles the parents, but the finality with which the race fixes this growth potential *is only relative.* Through the germ plasm of unnumbered generations of people the race exhibits an evolution-potential, and individual organisms in each successive generation are differentiations from this evolving pattern. *In each generation, certain offspring are not only unlike, but superior to their parents.* Look at the vast difference between the low level of intelligence found in prehistoric man and the level of our intelligence today. Somewhere, along the line, if offspring were not superior to their parents, how could evolution be a fact? This means that heredity *is not fixed* and that, all along in the history of the race, something *is* added to 'heredity.' Cutting across the evolution-potential, of course, are all sorts of factors such as the delete-

[1] Sharp, L. W., *Introduction to Cytology.* New York: McGraw-Hill, 1926.

rious effect of prolonged inbreeding. Yet, it should be recognized that two parents may both be seriously defective, perhaps in the same characteristics, and produce offspring all without personal defects; even two parents that are feeble-minded *may* produce normal children. This is because the faults of the two parents are traceable, insofar as inheritance is concerned, to defects in those parts of the germ plasm that do *not* happen to come together in the fertilization of the egg.

Because the defects of one generation frequently do appear in the offspring it cannot be predicted that the latter will always be superior to their parents. At the same time, the importance of environment, even after the child is born, is sufficiently great to justify efforts to raise the children, through proper care and education, to levels not reached by the parents. And above all, the implications of predeterminism, characteristic of previous views on heredity, must be overruled if the biological problems of society are to be solved adequately, and if the birthright of the individual child is not to be violated. To consider any child a hopeless case, either from a health or an educational standpoint, is to permit a false tradition to override scientific facts and principles.

Neither a good nor a bad inheritance is to be ignored, but a good inheritance is no certain guarantee of physical growth, intelligence, or success, nor is a bad inheritance a guarantee of permanent disability and worthlessness. The problem must be regarded from a relativistic standpoint. The more an individual is handicapped by unhealthful or undesirable hereditary factors, the greater the burden upon environment, medicine and training, if the individual is to develop into a normal adult. And up to the present time there are many infants born so defective that there is little to be done for them in the light of our present knowledge. Nevertheless, only in the rarest cases can it be said that efforts to bring the individual to a normal level physically and mentally yield no results whatever. On the contrary, the less serious the defect, the more environment and training can be made to compensate for it, even by present methods. And on the other hand, remember that training and environment may completely wreck an individual whose inheritance is called 'good.'

Environment of the Embryo. It is not logical to consider forces within the parent organism, external to the embryo, as hereditary forces. These are congenital factors, belonging on the side of environment. When the embryo, growing in the uterus, is malnourished, or through chemical defects in the mother's blood stream acquires certain physical deficiencies, the causes are certainly environmental with respect to the developing individual. For example, the mother may be deficient in secretions from the thyroid gland. As a consequence, the child develops nervous and physical disorders tracing back to its pre-natal life.

The organic environment of the growing embryo is important in other respects. The structure of the uterus in animals of the same species is approximately the same. Hence, embryos that grow inside of these organs are subject to relatively similar patterns of pressure, and pressure has much to do with the physical appearance of the organism. Try growing potatoes in hard soil *versus* soft soil! Note how a tree trunk, growing between two rocks, twists, turns, and flattens out, as its internal pressure adjusts itself to the resistance offered by the surrounding objects. It is becoming evident that at least one reason why different members of the same species resemble each other in important respects is the fact that they all grow in a relatively similar uterine environment of pressures and other forces. Another reason is the fact that they are fed with blood of much the same chemical composition. This field of investigation, namely, the influence of *organic* environment upon the growth of the embryo is relatively new, and information is meager, but as far as experiments have gone, it is necessary to count this factor on the side of environment, and to face the issue that environment begins to influence the organism the instant the ovum is fertilized. (Child.)

Limitations of Pre-natal Control. Experimental control of the growing embryo is limited, and is far more effective at the very early stages of the individual's life history than in the later stages, and far more effective on embryos of primitive than of highly specialized animals. This is because changes can be induced in the growing organism best when the tissues are undifferentiated. To illustrate, in primitive animals, tissue that

would have grown into an eye can be placed elsewhere in the organism and it will develop into something else, but the instant the original tissue becomes specialized in the direction of an eye, it is too late to transplant it and expect it to grow into other normal, healthy tissue. So it is that after the embryo reaches a fairly specialized stage, disturbing its tissues will either cripple or kill it.

These facts harmonize with what we know about the control of personality and intelligence. It is a familiar fact that the undifferentiated traits of an individual are laid down very early in life, and the older the person, the more difficult it is to effect a change. An infant born relatively feeble-minded might be treated medically in such a way that its nervous system could be improved. Then, still while a very young child, special training might be adopted to stimulate normal growth of the nervous system. If this same child were permitted to develop to the age of four, without medical treatment and special modes of stimulation, some improvement might still be effected. If the delay is postponed until the individual is twenty years of age, improvement would be relatively slight.

The Improvement Over Hereditary Conditions. The organism does not cease growing specialized tissues at birth. Growth, or changes akin to growth, continue throughout life. Therefore, just as one must take an embryo, early, if he wishes to alter its structure, so one must take the individual early in post-natal life, if marked improvements in intelligence and personality are to be induced. The reason why the earlier efforts to change intelligence are the more successful is not the fact that the nervous system becomes grooved by repetition into fixed habits of response. The explanation lies in the familiar laws of dynamics.

The less mature the organism the less highly specialized or structured its energy, and the less resistance it offers to change in accordance with the law of maximum work. On the other hand, in the mature nervous system, for example, more of the nerve cells are well developed, and they have a greater number of branches. These structurizations represent relatively stable forms of energy, adjusted, in one part of the system, to all the other parts. The more there are of these structures, the less the

nervous system as a whole will yield to gross changes. This does not mean that individual habits, after years of repetition, *cannot* be changed. It means that fundamental personality traits, represented by patterns pervading the entire brain, will undergo very little change. The system 'tends' to maintain its *status quo,* and the older and therefore the more extensive the processes of growth that have already occurred along abnormal lines, the more energy is required to change the *status quo.*

The Environment of the Germ Plasm. *The forces of environment reach back, beyond the fertilized cell,* to the organic environment of the male and female germ plasm, where physiological influences affect the germ plasm through the blood stream. It was formerly thought that the characteristics of this germ plasm depended solely upon the germ plasm of the ancestral line, and that no variation in the species could be brought about except by a spontaneous change in the plasm itself. The germ plasm is, to be sure, continuous from one generation to the next, but this continuous stream is subject to changes induced both by the organic environment in which it grows, and by external environment.

Effect of Treatment by Ultra-violet Rays. Experiments show that new species can be developed in the fruit fly by treatment of the germ plasm with ultra-violet light. We know that in its natural environment the living organism is constantly subject to the effects of these rays and of others, known as cosmic rays. In fact, one of the latest theories explaining the origin of new species in the animal kingdom supposes that rays, reaching the germ plasm in one generation, so change the genes that new species appear in the next generation.

Possible Effects from the Organic Environment of the Germ Plasm. There are other possible ways of affecting the germ plasm from environmental sources. It is known that in the blood stream of a living organism there exist several chemical substances, or hormones, that exert control over different tissues. These hormones are secreted by ductless glands, the pituitary at the base of the brain, the thyroid, the ductless sex glands in the male and female, the adrenal glands, the thymus and the pancreas. It is thought that the muscles give off a hormone that affects heart action, and very likely that other

tissues, also, produce specific chemical substances.[2] These hormones profoundly affect the character of tissues far removed from the place where the hormones are formed. The iodine content of the thyroid gland is necessary for a normal nervous system and for normal growth generally. The pineal gland on the upper surface of the midbrain secretes a substance that in part controls the development of secondary sexual characteristics, like the growth of adolescent hair. The pituitary is an important governor of skeletal growth. The adrenal secretion influences the nervous system, the liver, the intestinal tract and many other tissues. When there is a sufficient lack of pituitary, thyroid, and adrenal secretion, the sex organs fail to develop and function normally. Thus it can be seen that the chemistry of the body represents a complicated picture of a balanced, dynamic unit, in which the efficiency and normality of every part depends upon the efficiency and normality of every other part.

It is inconceivable that the germ plasm should be immune to this interdependence. In fact, the evidence just cited shows that it is not. Accordingly, any outside environmental influence, like food supply, climatic conditions and electrical effects from invisible rays, may alter the chemical composition of various glands. In turn, the altered composition of the blood stream would affect the germ plasm in ways that might produce variations in the offspring. Such possibilities as these demand extreme caution in assuming the fixed nature of inheritance.

The Logic of Inherited Capacity. Facts are not the only reasons for repudiating the old fatalistic and predeterministic point of view in regard to heredity. Logical considerations demand such a repudiation. 'Inherited capacity' is a contradiction in terms. What is a capacity? It must be a potential of some sort. But, by definition, a potential is not an independent existence; it does not *reside in* objects. Power is always relative, never absolute. A body exactly at the center of the earth *would have no capacity* to move with respect to the earth. The weight of an object is an indication of its 'capacity

[2] Cannon, W. B., and Bacq, Z. M., "Studies on the Conditions of Activity in Endocrine Organs." *Amer. J. Physiol.*, 1931, Vol. 92, 392-412.

to move,' because weight measures a gravitational potential. At the center of the earth the object would weigh nothing! 'Capacity to move' depends upon the object's *position* in a gravitational field.

Growth is movement. There would be no capacity to grow where there was no environment. *The seed has no potentialities where there are no heat, light, pressure,* and *chemical nourishment. The capacity is a potential that, for its existence, depends upon environment.* Inheritance, therefore, means nothing as a factor by itself. The genes, of course, determine in part the direction of growth processes. Dog genes are essential for dogs; human genes are essential for human beings. At the same time, there is no inherited 'capacity' that is not as dependent upon environment as upon the race. Inheritance is inheritance only because there is environment and environment is environment only because there is inheritance.

The Function of Environment. *The function of environment is to raise the growth potential, not merely to permit its expression.* Inheritance does not supply enough energy for growth, or for intelligence. It provides the *start,* and when other things are equal, the *direction,* of growth. A fertilized cell laid out on the cement floor would instantly die! Heredity is potent, and yet so impotent! Measured in terms of energy, inheritance amounts almost to nothing! This is not denying its importance. One cause of growth *is* heredity, but as compared with environment, heredity contains only a few of the conditions necessary for growth.

The real function of environment in the production of an organism may be understood with the aid of an analogy. A very sluggish stream of water flows through a canyon. There is no power in the stream; it can achieve nothing. But an engineer builds a dam across it, raising its level two hundred feet. Now the stream rushes over the top of the dam and at the bottom turns mighty engines that supply power for a radius of many miles. *A potential has been raised by elevating the stream. Now there is achievement.*

Environment raises the potentials of 'heredity' by supplying air, food, heat and stimulation. This energy accumulates behind billions of membranes in the nerve and muscle cells of the

body, to be expended in thought and action. Then, and only then, are there intelligence and achievement.

It is a contradiction in terms to insist that the stream of water, before its level was raised, possessed a capacity for work. There was no capacity, for its capacity depended upon a raise in level. Then, when the level of the stream was raised, it had 'capacity' which was realized in the gravitational force with which it fell. *Capacities are dynamic relations between things.* It is an error, therefore, to say that a human being at birth has the 'capacity' for intelligence. He has very little capacity for anything; he is a helpless, impotent creature, but, like the stream, *a possibility, if something is done to create capacity.* Of course, when the stream is shallow and the water supply is low, there is little that can be accomplished by building a dam. Where the infant has a seriously defective nervous system, weak lungs, weak heart, and abnormal glands, little can be accomplished by a good environment.

The Function of Education in Relation to Heredity. Now we know the function of Education. Its aim is to raise the energy of the growing organism to higher potentials through stimulation and motivation. It does more than permit intelligence to express itself; *it creates intelligence,* just as building a dam creates water power. Education raises the energy level of the organism and directs it into channels for the performance of a type of work that we call achievement. Its function is that of a concentrated environment designed to raise these potentials faster and higher than would be possible without planned and systematic effort. Unfortunately, Education fails in this purpose, for it is an easy matter to find self-educated men who are far more intelligent and have achieved more than those who have graduated from our educational systems!

The Problem of Intelligence. The laws of dynamics render meaningless the concept of inherited endowment. Only when the growth potential is raised by environment is there intelligence, and then it is acquired. 'Capacity' is a *derived* property.

Moreover, in terms of dynamics, there would exist no possi-

bility of measuring a *native* capacity, or potential, if one existed. The only kind of energy that can be measured is *kinetic* energy, or work. This is energy in the process of being expended. *In human life we call it achievement. Potentials are never measured; they are always inferred.* One can measure the force of a falling body by letting it strike an obstruction; one can measure an electric current in terms of the resistance that various substances offer to its passage; one can measure temperature in terms of the contraction or expansion of objects which temperature induces. In these cases one is measuring work that a 'force' is doing; the 'force' is the consequence of a DIFFERENCE in potential. Thus, a flow of energy is being measured, conditioned by the extent to which parts of a field of potentials are off balance. When the force of a falling body is measured, it is the consequence of a difference in gravitational potential between the position from which the body started, at a certain altitude, and the center of the earth. When an electric current is measured, it is the consequence of a difference between a high charge and a low charge in an electrical field. When the temperature is being measured, it is the consequence of a difference between a high and a low thermal stress. In all these cases, motion that would end in the resolving of a stress is the process that is measured, or in other words, it is the kinetic energy with which a body or a current is approaching a remote end or goal! Nothing 'native' or 'inherent' enters the picture.

Intelligence as Human Work Called Achievement. When an intelligence test is given to a human being, some indication is obtained of the difference in potential between the individual's desires and ideas, and the goals toward which these ideas and desires are directed. *It is human work, kinetic energy, in the form of achievement that is being measured.* The achievement takes the form of solving problems; solving a problem is the energy of a goal-idea 'flowing' to a remote end. A real intelligence test is measuring an individual's will as much as his intelligence, his personality as much as his reasoning, his emotional life as much as his judgment. It is measuring the organization of his forces toward achievement, and the achieve-

ment is an expression of derived potentials. The achievement, however, not the potential, is being measured. As a psychological phenomenon, this achievement is insightful response.

Further Misconceptions of Intelligence. There is another misconception concerning intelligence. It should not be concluded that tests measure a person's *limit of activity,* for if the conditions under which he takes the test are changed, his performance will inevitably be changed. According to the conditions that are changed, his achievement will be better or worse. For example, many college students, who, as freshmen, rank near the bottom of their class in intelligence scores, rank at the top in a similar type of test before they complete their course. *They were actually dull at the outset, and had showed dullness for years previously, but as the consequence of a stimulating environment, were brilliant at the finish. Thus the validity of any prediction, based upon a test, depends upon the constancy of the conditions under which the individual is maturing.*

The So-called Constancy of I.Q. In order to illustrate this point again, consider the case of an alleged feeble-minded boy, who, at the age of 12, had a mental age comparable to a child of 8. The boy's intelligence quotient (I.Q.)—the ratio of his performance to the average for his actual age—was 67, as compared with the norm of 100. When he took an intelligence test for the first time he was stunted in physical growth and had been leading a very quiet life at home, where there had been no systematic attempt, for several years, to stimulate his mental development. He was then taken to an expert diagnostician who made practically all of the tests of metabolism known at that time to medical science. The boy was prescribed a special diet, given thyroid treatment, and at the same time placed in the hands of a trained teacher. Within two years he had grown considerably more than could have been expected without medical treatment, and the soundness of his physical condition had vastly improved. He was tested again, this time at the age of 14, when his mental age was 12, and his intelligence quotient was 86. How much of his improvement was ascribable to medical treatment is uncertain, *but the boy was able to meet new problem situations which he had never solved*

before, demonstrating that his mental development was not the consequence of mechanical drill.

It often happens, to be sure, that intelligence quotients remain constant over a long period of time, and for this reason the constancy of the I.Q. has been accepted as a general law. *It is a law only because the conditions under which children develop remain sufficiently constant to produce a constant rate of mental growth.* There is no reason whatever for asserting that because a child at the age of six has an I.Q. of 60, that he must have only an I.Q. of 60 when he is 12 or 15. *Such a claim violates one of the most cardinal principles in science, namely, that any event is the product of existing conditions. And conditions can be changed.*

Intelligence of Adopted Children. Several important investigations of the nature-nurture problem have been completed within the last few years. One of these is an elaborate study of adopted children.[3] Important among its results are the following:

(1) Of 26 children, born of feeble-minded parents, only 4 had I.Q.'s below 70, sometime after adoption. The average I.Q. was 81, which is considerably higher than is to be expected if feeble-mindedness follows, exclusively, the chance laws of inheritance. In general the mentality of the blood parents of the children was low, yet the I.Q.'s of such children were equal on the average to the standards for children in general.

(2) Unrelated children adopted into the same home came to resemble one another in intelligence.

(3) When siblings (brothers and sisters) were separated in different types of homes, these differences in environment produced greater variations in intelligence than were evident before the separation. Ordinarily the resemblance between intelligence in siblings can be expected as .50, the 'coefficient of heredity.' When siblings were separated but sent to similar homes the effect was a reduction of this coefficient to the range .30 to .37 for sixty-two pairs. When they were sent to homes of dissimilar culture the effect on sixty-three pairs was to reduce the coefficient of heredity to the range between .19 and .28.

[3] Freeman, *et al., 27th Yearbook of the National Society for the Study of Education.* Part I. Bloomington, Ill., 1928, 102-218.

(4) Early placement in good homes was an important factor in determining the intelligence level of the child. Improvement in intelligence was evidently more dependent upon the type of home than upon age of placement. *It was obvious, therefore, that an improvement in environment conditioned a definite improvement in intelligence.*

Definition of Heredity and Environment. It is certain that the more the environment of the developing organism is brought under control, and the earlier in the life-history of the organism the control is effected, the more the organism can be changed for better or for worse, depending upon the type of condition selected. Basically, *inheritance must be defined as those conditions of growth that are for the time being under the control of the race. Environment consists of those conditions of growth that are at present subject to control.* Education, of course, belongs on the side of environment. There is, therefore, no logical distinction possible either between inheritance and environment, or between an intelligence called native and one that may be called acquired. On the contrary, mental development is a function of *one, not two,* sets of conditions, and these conditions all obey the laws of dynamics.

A Warning About Conclusions Regarding Inheritance. The student may find in the literature numerous investigations, experimental and statistical, from which conclusions are drawn relative to the extent of influence heredity exerts upon the organism as compared with the influence of environment. *Such conclusions are always unsafe,* for there is no place where heredity ends and environment begins. We are told of the overwhelming percentage of feeble-minded and persons criminally inclined, from the descendants of famous morons and notorious criminals. We are also reminded that superior persons are more likely to predominate among the offspring of statesmen and other geniuses. *These figures, true as figures, fail to measure, however, the influence of heredity.* The offspring in question were not moved from the environment in which they were born and subjected to reverse conditions. No one knows what the outcomes would then have been, but we do know that normal children can be made feeble-minded and, within striking limits, *vice versa.* The importance of healthy

parents cannot be overestimated, for without them, a burden is then placed on environment that may very well be beyond our knowledge to cope with adequately, if we are to produce healthy individuals. *An increasing knowledge of how to compensate for a defective 'inheritance' is no excuse for a 'bad inheritance.' On the other hand, a defective 'heredity' is no excuse for the dogma that its victims are helpless.*

Social Status as a Condition of Intelligence. Figures like the following [4] have been offered in 'proof' of native endowment, but they might equally as well be offered in 'proof' of social environment as a condition of intelligence. Nothing is proved relative to the nature-nurture problem beyond the fact that the individual is the product of a total situation.

TABLE I

RELATION OF INTELLIGENCE RATINGS TO SOCIAL STATUS

Occupational group	Median I.Q. of children in the grades	Median I.Q. of children in high school
1. Professional	116	121
2. Business and clerical	107	112
3. Skilled labor	98	108
4. Semi-skilled labor	95	108
5. Farmer	91	106
6. Unskilled labor	89	111

Children from the better social environments in which economic advantages make possible more stimulation of the child, and in which more culture and learning in the home provide greater opportunities for development, are, on the whole, superior to children coming from a more limited economic and social environment. In the superior home, more ideas are expressed by the child's associates, more questions are asked and answered, and more encouragement is given for advancement. These influences tell extremely upon the child, even in the first three years of its life, so that children tested at the preschool age are often superior, if from professional homes, and relatively inferior, if from the homes of unskilled laborers. It

[4] Haggerty, M. E., and Nash, H. B., "Mental Capacity of Children and Paternal Occupation." *J. of Educ. Psy.*, 1924, Vol. 15, 559-573.

is almost safe to conclude, however, that the younger the children, the less the difference, showing that as the child matures, the importance of the social environment increases and causes the levels of intelligence to diverge.[5]

One may argue, of course, that intrinsically more intelligent parents find their way into the more remunerative occupations; thus, on the basis of 'inheritance,' we would expect to find superior children among the professional classes. The answer to this argument is that the parents themselves were, on the whole, raised in more stimulating environments and thus developed higher intelligence. In short, the sooner the nature-nurture argument is concluded and efforts made to educate parents and children in matters of health and culture, the better off society will be.

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[5] Compare, for example, the statistics from F. L. Goodenough, *The Kuhlman-Binet Tests for Children of Pre-School Age,* Uni. Minn., 1928, 45-49; and those of Duff and Thomson, *Brit. J. Psy.,* 1923, Vol. 14, 192-198; J. E. Collins, *J. Educ. Res.,* 1928, Vol. 17, 157-169; and Haggerty and Nash *op. cit.*

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CHAPTER X

THE MEASUREMENT OF INTELLIGENCE

Intelligence Tests

The Selection of Material for Intelligence Tests. The preliminary material for an intelligence test is selected merely from a common sense knowledge of behavior. So it was with Binet, who for several years prior to the formulation of his test scale in 1908, had been studying the mental development of his own children. With a knowledge gained in this work he selected a set of problems fitting the different stages of mental development in the child between the age of 3 to 15. Later, he added certain tests for adults. If from about 65 to 75 per cent of children of a given age were able to answer the questions for that age he regarded the tests as satisfactory. A child who was able to pass tests designed for older children was regarded as superior, and one who was not able to pass the tests for his age was considered inferior.

The Mental Age Concept. If a child is just able to pass the test which the majority of children of his age are just able to pass, he is said to be mentally as well as chronologically of that age, and normal. This means, for example, that the average or normal eight-year-old child has a mental age of eight years. However, if an eight-year-old child is just able to pass the ten-year tests he is said to have a mental age of ten and is accelerated two years, mentally. If he is eight and has a mental age of only six he is retarded to the extent of two years of mental age. *Thus a year of mental growth becomes a rough unit of measurement.*

The Intelligence Quotient. In his revision of the Binet scale, Terman assigned values to each of the tests within the different year-groups and added certain questions making it possible to evaluate each single test in terms of a score composed of month-units. Terman also adjusted the items in the

test and devised methods of scoring the items in such a way that each year represented approximately equivalent increments of mental development. This permitted measuring the mentality of the child, no matter at what age, in terms of the ratio between his actual performance and the average performance for his chronological age. This ratio is known as the *intelligence quotient* (I.Q.). It is obtained by dividing the standard score for a given age, which is a point for each month, into the actual score obtained by a child of that age. The normal I.Q. is therefore 100. Thus, the standard score for six-year-old children is 72, a point for each month of chronological age. Suppose a six-year-old child passed all the seven- and eight-year tests; he then obtained a score of 96 which gave him a mental age of eight and an I.Q. of 133. Had he passed only the five-year tests he would have an I.Q. of only 83. There are obvious advantages of the I.Q. over the mental age as a measure of intelligence. A child six with a mental age of three is relatively more retarded in mental growth than a child fourteen with a mental age of eleven. Accordingly, to interpret a mental age properly one must know the individual's chronological age. On the other hand an I.Q. classifies an individual either at the age of six or at some other age, like eleven, in approximately comparable terms.

Classification of Intelligence Levels According to I.Q. I.Q. classifications are not reliable beyond the age of about fifteen years. Because of this relatively uniform significance of I.Q.'s under the age of 15, it was possible for Professor Terman to establish the following classification of intelligence levels.

TABLE II

INTELLIGENCE LEVELS ACCORDING TO I.Q.'S

I.Q.	Classification
Above 140	Near genius or genius.
120-140	Very superior intelligence.
110-120	Superior intelligence.
90-110	Normal or average intelligence.
80-90	Dullness, rarely feeble-mindedness.
70-80	Borderline deficiency, often feeble-mindedness.
Below 70	Definite feeble-mindedness.

Practical Classification of Intelligence Levels on Mental Age Basis. On the basis of tests like the Stanford Revision, individuals are classified as feeble-minded who have reached the age of 15 or 16 with a mental age below 12.

Persons whose mental age is one year or less are helpless. All those of 3 years of mental age or under are called idiots; they can not learn to work or play except in occasional instances. Persons from 4 to 7 years mental age are classified as imbeciles, the higher grades of which can learn to perform simple tasks. The mental age range from 8 to 12 constitutes a class known as morons. Low grade morons are able to perform a variety of routine tasks under supervision. The high grade morons can learn fairly complicated tasks such as using machinery, caring for animals and gardening, but they need occasional oversight because they can not plan and show almost no initiative when things go wrong.

Types of Intelligence Tests. There are two general classifications of intelligence tests; first, group as opposed to individual tests, and second, language as opposed to performance tests. Performance tests avoid the use of language, and are especially adapted for the examination of foreigners and illiterates. Group tests are relatively late developments in testing methods, while both the performance and language types of individual tests are of fairly early origin.

Examples of Items in Group Intelligence Tests. The items which comprise an intelligence test require the subject to apprehend various kinds of relationships, especially abstract relationships. The following are sample items of a test making use of *same* and *opposite* meanings. The individual is asked to draw a line under *same* if the two words of a pair mean the same, and to underline *opposite* if the two words have opposite meanings.

low-high	same	opposite
shy-timid	same	opposite
reverence-veneration	same	opposite
amplify-condense	same	opposite

A greater variety of relationships is involved in such a test as the following, which is called an analogies test.

shoe : foot :: hat : VEST SCALP KNEE HEAD
tolerate : pain :: welcome : UNWELCOME NUISANCE DESIRE PLEASURE
picture : see :: sound : HEAR NOISE OPERA EAR

What word, for example, bears the same relationship to hat as foot bears to shoe?

Still a different method of testing the comprehension of relationships is illustrated by a test like this in which the individual is instructed to check the best answer.

Everyone should be educated because :
.....leaders are educated.
.....it provides employment for teachers.
.....everyone should know how to read.
.....X.....it makes a person more useful.

The following are samples of an information test often used because the range of a person's information is roughly proportional to the ease with which he apprehends abstract relations. The instructions are to underline the word which best completes the sentence.

Snow falls in AUTUMN SPRING SUMMER WINTER.
The terrier is a GOAT RAT DOG FISH.
Bile comes from the KIDNEYS LIVER SPLEEN STOMACH.
John Sargent was a well-known WRITER STATESMAN SCIENTIST PAINTER.

Reasons for Large Number of Items in an Intelligence Test. In constructing an intelligence test large numbers of items are used for several reasons. *First,* with individuals raised in different environments and having different life-interests, a similar score in the test will not mean the same for one person as for another unless the items are sufficiently numerous to give each person an equal chance. *Second,* there must be a sufficient number of items graded in difficulty to differentiate those persons who can comprehend only the simpler relationships from those who are able to grasp more complex relationships; there must be an appropriate number of items not

too hard for dull individuals and not too easy for individuals who are brilliant.

Third, a wide range of facts and relationships must be covered to avoid making a test of specialized interests and aptitudes.

Fourth, the items thus varied and graduated must yield results that can be expressed in terms of numbers, *and these numbers must represent the relative position of the individual in the group. His achievement must be compared with the average of the group.* To ascertain this relative position of the individual in the group the results of the test are treated statistically. Accordingly, large numbers of varied items are useful in reducing the size of chance errors.

Statistical Procedures

Necessity of Checking a Test Against a Criterion. If a test is to be applicable to conditions in life the results which it yields must bear some definite relation to the individual's achievement in life so that a prediction can be made on the basis of the test. In other words, the test must be checked against a *criterion.* The criterion may be grades in school, teacher's estimates of brilliance, success in the vocations or what not, provided it can be *measured.* The checking of a test against a criterion is accomplished by means of a statistical method called *correlation.* Some of the mathematical procedures upon which correlation is based are to be discussed briefly in the following pages.

The Frequency Distribution. Measurements dealing with mental traits, like measures dealing with physical traits, fall into what is known as a *continuous series.* Any unit of measurement used in obtaining this series is chosen as a matter of *convenience,* not because there is a unit existing in nature corresponding to that particular unit of measure. There is no unit in nature corresponding to the inch, yet height is measured in terms of inches, neither is there any unit corresponding to the pound, yet weight is measured in pounds.

Suppose that ten thousand men have been weighed. There would not be an equal number of men weighing 85, 95, 105 and

115 pounds, respectively, on to the heaviest which might be 245. There would be a certain weight, perhaps 165, which would represent more individuals than any other given weight. Then there would be a large number weighing around 160, but not as many as would weigh 165; likewise a large number weighing 170 but not as many as would weigh 165. With 165 as a convenient starting point, and using ten-pound intervals,

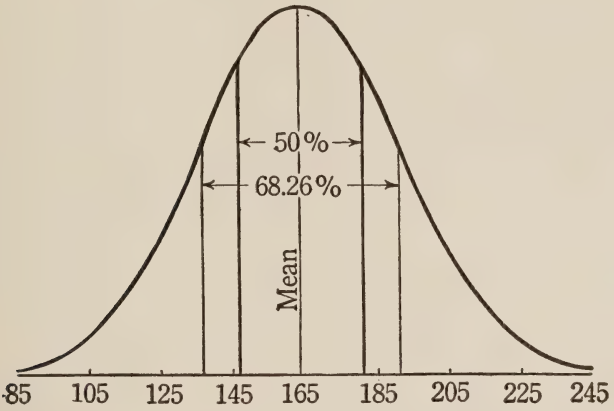

FIG. 26. A THEORETICAL NORMAL FREQUENCY CURVE.

Showing a hypothetical distribution, and the areas measured by the standard deviation (68.26%) and probable error of the distribution (50%).

there would be found among these men fewer and fewer who weighed each of the smaller amounts, until either extreme of the range of weights had been reached. Furthermore, this tapering off of the numbers of men in each of the weight-groups would occur at about the same rate going either up or down the range. There would be a *continuous* series of measures from lowest to highest with a known frequency of any given measure along the series.

Normal Curve of Distribution. These frequencies approximate a theoretical curve when properly plotted. (Fig. 26.)

The distance of this curve from any point along the base line represents the number of times a particular measure occurred. Note, for example, that the measure occurring the greatest number of times was 165 and that the measures occurring the least number of times were 85 and 245. A curve

such as these frequencies approximate is called a curve of normal distribution of measures because it holds in so many instances in which a heterogeneous group of related objects is measured for a particular trait.

Interpretation of the Normal Curve. A normal distribution of measures is obtained in a situation where no attempt is made to control the objects that are measured. In the illustration mentioned above there was no selection of the men. None of the factors bearing upon the weights of the men were known. The conditions under which the men had been raised, the types of food they had eaten, their inheritance, their occupation, and general health, would all help to determine the measures. It is evident that the men were taken just as they came; hence there was a chance distribution of measures. Other things being equal, a chance distribution gives a normal probability curve.

Uses of the Normal Probability Curve. So often is this curve found in psychological measurement that it has sometimes been accepted as a standard to which test-scores are made to conform before the tests are used in locating an individual in the group with respect to any particular trait. This procedure, however, is purely arbitrary. However, the curve is very convenient, for because of its peculiar character several mathematical formulae can be employed which enable us *to predict the position of an individual in the group with respect to the trait measured.* Now, in any given instance, if a relatively large number of measures are closely bunched about the measure of greatest frequency, we will get a curve with a steep slant; measures scattered widely will give a gradual slant. This slant, as well as the most frequent or central measure, is an important characteristic of the curve. In the ideal distribution this most frequent measure, called the *mode,* is also the *average* of the measures and it is likewise the *median* or the middle measure between the smallest and the largest. In most actual distributions these values do not coincide.

The mode, average and median are called measures of central tendency. They are values about which the largest numbers of measures cluster. There are other mathematical values which represent the amount of this clustering, or better, the

extent of scattering or *deviating of measures from the average and median.* These are called the average deviation, the standard deviation and probable error, all of which will be explained in their turn.

Measures of Central Tendency. The measures of central tendency which are used most frequently are the average (mean) and the median. The formula for computing the average is

$$A = \frac{\Sigma \text{ Measures}}{n} \qquad (1)$$

which is to be interpreted as follows: The average is equal to the sum of the measures divided by the number of cases.

The median is the middle measure of a series when all the measures are arranged in order of size from lowest to highest or *vice versa.* The formula reads:

$$M = \frac{n+1}{2} \qquad (2)$$

The median falls at a given case when there is an odd number of measures. When there is an even number of cases the median lies between the two middle cases.

In order statistically to locate an individual in the group, with respect to his score in a particular performance, either the average or the median must be known. For rough placing, the method is simply to ascertain the position occupied by a given individual's score in the total range of scores from lowest to highest. By using the *median as a point of reference* it can easily be determined whether a given score falls in the upper or the lower half of the range. Somewhat more precise is the method of dividing the range into four parts, called *quartiles.* Then it can be determined by inspection whether *A*'s score is in the first or highest quartile, the second, the third or the fourth. Still more precise is the method of transposing all scores into percentages, calling the highest score one hundred and the lowest, zero. Then a person's score places him with respect to one hundred divisions of the total range instead of four. These divisions are known as *centiles.* It is frequently convenient to group these one hundred divisions into ten parts,

or *deciles,* and to rate each individual's score 1, 2, 3, . . . to 10 according to the decile into which it falls. In many of the universities that give intelligence tests to entering freshmen, original scores are converted into decile ratings. An individual is given a rating of 1 if his score is among the highest 10 per cent of the scores, 2 if it is in the next to the highest 10 per cent, and so on.

Measures of Variability or Scatter. For more accurate work other procedures are necessary, *based upon the average as a point of reference.* Here more definite measures of the scattering of scores from the average must be available. Remember that the original distribution of scores was a chance distribution. It might be, therefore, that if the same test was given to a group over again, discounting the effect of taking the test twice, each subject would obtain a different score. The probable size of this error must be measured. A convenient first step in ascertaining the degree of this chance scattering of scores is to find the average deviation of individual scores from the average. The formula is:

$$A.D. = \frac{\Sigma D}{N} \qquad (3)$$

(The average deviation equals the sum of (Σ) the individual deviations, disregarding the signs, divided by the number of cases.) After the plus or minus deviation of each score from the average is found, the plus deviations should total to the same amount as the minus deviations.

The next step in measuring scatter is to compute the *standard deviation* (*sigma*) the formula for which is:

$$S.D. \text{ or } \sigma \text{ (}sigma\text{)} = \sqrt{\frac{\Sigma D^2}{N}} \qquad (4)$$

(The standard deviation, or *sigma,* equals the square root of the sum of the deviations squared, divided by the number of cases.) First, square each of the separate deviations, then find the sum of these squares, add, divide by the number of cases, and extract the square root.

Value of the Standard Deviation. It is often desirable to know whether a certain individual attained as high a score, relatively, in one type of test as he attained in another. Then it is necessary to compare his position in the group with respect to his score in one kind of performance, with his position in the group with respect to his score in another kind of performance. To accomplish this, both sets of scores must be *reduced to common terms* by finding the standard deviation of each set of scores and then expressing the deviation of any individual score from the average as a multiple of the standard deviation. Suppose a certain individual obtained a score of 200 in an intelligence test, which was a deviation of 100 above the average score of the group. The standard deviation for that group, let us say, is 25. We can then express the score as + 4 *sigma.* Suppose this person obtained a score of 80 in a chemistry test and that it was a deviation of 40 points above the average. Then, assuming for convenience that the standard deviation for the chemistry test is 20, the chemistry score can be expressed as + 2 *sigma.* Both scores have been reduced to common terms and we know that the person taking the examinations did not receive as good a score relatively in the chemistry test as he obtained in the intelligence test, and that in one test he was exceeded by a certain number of individuals and in another by a certain number.

Definition of the Standard Deviation. To obtain a clearer conception of what a standard deviation means let us return to the normal frequency curve. While the S.D. does not depend upon a curve of distribution it may conveniently be represented on one. On the surface inclosed by a normal probability curve a perpendicular may be erected at the point representing the average, and certain other points found along the base line (base line represents the range of scores from lowest to highest) that represent the range of the standard deviation, both plus and minus. If perpendiculars are erected at these points *an area has been inclosed that covers approximately 68 per cent of the measures.* Thirty-four per cent of the scores will be plus deviations and will fall between the average and the right hand perpendicular; 34 per cent of the scores will be minus deviations and will fall between the average and the left

hand perpendicular. *This range between the perpendiculars* represents the standard deviation. (*Cf.* Fig. 26.)

The Probable Error. Next come additional measures of scatter, called the probable errors of the distribution and of the mean. The former is computed from the standard deviation by using the formula:

$$PE \text{ (dis.)} = .6745\,\sigma \tag{5}$$

$$PE \text{ (av.)} = \frac{.6745\,\sigma}{\sqrt{N}} \tag{6}$$

The former signifies that particular range of measures, with the average as its mid-point, within which 50 per cent of the measures fall. Upon giving the test again the chances are one to one that a particular score will fall inside or outside of this range. It is an indication, therefore, of the extent to which a particular score represents a true value, when the distribution of scores is assumed to be 'normal.' The latter formula signifies that at another time the chances are one to one of the average falling within the range indicated by the probable error. Thus we have an indication of the extent to which the average is a true value.

Probable Error of the Difference Between Means. One of the most common problems involved in the use of tests is the determination of a difference between the averages of two sets of data. Suppose we desire to know the difference between the average 'capacity' of boys and girls in arithmetic. The boys might be found to excel the girls, but this difference might not be significant. One must know the degree of reliability of the difference, which may be found in accordance with the formula:

$$PE \text{ (diff.)} = \sqrt{\frac{PE_1^2}{n_1} + \frac{PE_2^2}{n_2}} \tag{7}$$

This means square the probable error of the average of the first set of data and divide by the number of cases; square the probable error of the average of the second set of data and divide by the number of cases in this set; add the results from these two operations and extract the square root. Before a dif-

ference in two averages is reliable it should be 4 times the probable error of the difference.

Correlation. The usefulness of an intelligence test lies in our ability to predict from it the probability of the same individual's success along some other line, such as mastering the subject matter of chemistry, passing a college course or handling a responsible business position. These predictions depend upon a rather elaborate use of the standard deviation in a procedure which has already been mentioned, namely, *correlation.*

When two series of measures correlate well, it means that deviations from the average in one series occur in the same persons' scores in relatively the same amounts, and in the same direction, in the other series. The amount of correlation is expressed by a coefficient which varies from — 1 through 0 to + 1. Plus 1 means a perfect positive correlation; — 1 means a perfect negative correlation. In the latter case deviations from the average in one series occur in the same persons' scores in relatively the same amounts but in the *opposite* direction from the average in the other series. Zero means that there is no consistent relationship between the deviations from the average in the same persons' scores in the two series. Coefficients of correlation between — 1 and 1 are expressed in decimals such as — .32 and + .65

The Rank-Difference Method of Correlation. One of the simpler but less reliable methods of computing a correlation is the rank-difference method. (Not based upon σ but upon a substitute in the form of a rank-difference.) Suppose a group of individuals took an intelligence test and also a test in chemistry. The first step in the procedure is to rank each individual score in both tests, calling the highest score 1, the next highest 2, the next highest 3, and so on. Then the rankings are arranged in columns so that the two ranks for the same individuals are opposite one another. The second step is to find the difference in the two rank values for each individual. The third step is to square the differences and to find six times their sum. This gives the numerator of the formula. The fourth step is to square the number of cases and to subtract the whole number 1 from the product, then to multiply the result by the

number of cases. This gives the denominator. Finally, the numerator is divided by the denominator and the result is subtracted from the number, 1. The formula reads:

$$\rho = 1 - \frac{6\Sigma D^2}{N(N^2 - 1)} \qquad (8)$$

More elaborate procedures of correlation are required in most statistical work in connection with tests, involving the Pearson Product-moment method, the regression equation, partial and multiple correlations.

Exercises in Computation. In order to illustrate the computations just discussed suppose the following examples be employed.

TABLE III

DATA FOR COMPUTATIONS

I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Case	Reaction Time	D (from Average)	D^2	Rank	Mental Age	D (from Average)	D^2	Rank	D (of Ranks)	D^2
A	150	9	81	3.5	11.0	0.6	0.36	4	0.5	0.25
B	160	1	1	6	10.0	0.4	0.16	6	0	0
C	140	19	361	2	12.0	1.6	2.56	2	0	0
D	170	11	121	8	8.0	2.4	5.76	9	1	1
E	160	1	1	6	9.0	1.4	1.96	8	2	4
F	190	31	961	10	7.5	2.9	8.41	10	0	0
G	150	9	81	3.5	9.5	0.9	0.81	7	3.5	12.25
H	130	29	841	1	15.0	4.6	21.16	1	0	0
I	180	21	441	9	10.5	0.1	0.01	5	4	16
J	160	1	1	6	11.5	1.1	1.21	3	3	9
Totals $n=10$	1590	132	2890		104.0	16.0	42.40			42.50

Note the Table above. We have recorded a set of reaction-times in thousandths of a second (Column II) and mental ages in years (Column VI) of 10 people designated by the letters from A to J (Column I). Reaction-times measure the speed with which a person can respond to a stimulus.

To find the *average* reaction-time, we would apply formula

(1). In this case n equals 10, and the sum of the measures (Column II) is 1590. Substituting in the formula, we get,

$$A = \frac{1590}{10} \text{ or } A = 159.$$

In a similar way we might find the average mental age for these subjects. In this case the sum of the measures (Column VI) is 104.0 and n is the same. Then,

$$A = \frac{104}{10} \text{ or } A = 10.4.$$

In order to find the median of either group of measures we have to put the cases in order from the best to the worst. Notice the ranks in Column IX. The highest mental age, 15.0, is given the rank, 1, and the others in order down to 7.5 which is given the rank, 10. From formula (2), we know that the median is the case with the rank of $\frac{n+1}{2}$. In this case it would be 5½ or midway between the fifth and sixth cases. The fifth, Case I, has 10.5, while the sixth, Case B, has 10.0. The median would then be 10.25.

The procedure in the case of the reaction-times involves an additional feature inasmuch as a number of cases have the same values. The procedure is regular for the first two ranks, Cases H and C. Cases A and G both have 150, so, in order to treat them equally, we divide the next two ranks between them, giving each 3.5 instead of one, 3, and the other, 4. We cannot give 3 to both because we must have 10 ranks to correspond to the 10 cases. Also, B, E and J receive the same value, 160, so we divide between them the ranks, 5, 6, and 7, giving each one the rank 6. Thus we see that in this case the median, midway between the fifth and sixth cases would be 160. (A simple method of getting the median is merely to count up or down to the middle case from the end of the column of measures, provided they are arranged in order of their size.)

Having found the averages of the sets of data, we may now find the values of the average and standard deviation. Notice Column III. Here in each case we have found the difference

or deviation from the average, 159. Trace down the column and see how each of these values is obtained. The formula for the average deviation may now be applied. The sum of the deviations is 132 (Column III) and n is 10. Then,

$$A.D. = \frac{132}{10} \text{ or } A.D. = 13.2.$$

Compare this with the standard deviation. For this, each of the deviations must be squared as shown in Column IV. Applying formula (4), we get

$$\sigma = \sqrt{\frac{2890}{10}} \text{ or } \sigma = \sqrt{289} = 17.$$

The corresponding values can be worked out for the mental ages. The differences from the average, 10.4, are shown in Column VII, and the squares of these deviations in Column VIII. The resulting values are, respectively,

$$\text{A.D.} = 1.6.$$
$$\sigma = \sqrt{4.24} = 2.06.$$

The values of the probable error both of the distribution and the average may be found in a moment from the standard deviation. Applying the two formulas (5) and (6), we get the following results for the reaction-times.

$$\text{P.E.}_{\text{dis.}} = .6745 \times 17 = 11.47.$$

$$\text{P.E.}_{\text{av.}} = \frac{.6745 \times 17}{\sqrt{10}} = 3.63.$$

The corresponding values for the mental ages are 1.39 and 0.44.

Finally, we want to find the coefficient of correlation between these two sets of data that we have hitherto treated independently. For this purpose we have already ranked our material. In case we should not have done that, it would be necessary to stop and rank the data at this point. It should be noted that the original, raw data *can not be used* with this formula.

Given the two sets of *ranks* the first step is to find the dif-

ferences between the two ranks in each case. (See Formula 8.) Thus, in our table, Column X represents the differences in the ranks that we find in Columns V and IX, respectively. This may be followed across for each case. The second step consists of squaring these differences, the results to be found in Column XI. Now we are ready to apply the formula. The sum of the D^2 column is 42.5, and n is 10. Then,

$$\rho = 1 - \frac{6 \times 42.5}{10 \times (100 - 1)}.$$

$$\rho = 1 - \frac{255}{990}.$$

$$\rho = 1 - .258.$$

$$\rho = + .742.$$

Now suppose that Column II represents the reaction-times of a group of *boys*. Let a similar set of reaction-times for a group of girls be 120, 130, 170, 160, 140, 180, 190, 110, 150 and 100, so that we may have a set of figures from which to compute the probable error of the difference between two averages. The average for the boys is 159; for the girls it is 145. The difference is 14 thousandths of a second. The girls were superior to the boys in the quickness with which they could react to a stimulus. The probable error of the average for the boys has already been computed, 3.63. Compute the probable error of the average for the girls, in the same way, and we obtain 6.0. Using formula (7) the probable error of the difference is about 2.2, a little larger than one seventh of the difference which means that the difference is fairly reliable.

The Uses and Interpretation of Test Results

Practical Values of Intelligence Tests. (1) In the more progressive school systems where funds are available, research bureaus are maintained with a staff of testers who locate the mentally retarded and accelerated children. The retarded are placed under teachers who are trained to cope with the problem

of the atypical child. As a consequence, instruction of regular classes is more efficient. On the one hand, the child who is unable to keep pace with the average of the group claims much of the teacher's attention and delays the progress of the other pupils. On the other hand, if left in a group whose rate of learning is much slower than his, the accelerated child learns habits of laziness and indolence, and interferes with the progress of the class by giving constant disciplinary trouble.

(2) Tests are useful in high schools in giving vocational advice, in helping the student select his course, and in determining the rate at which the student should attempt to advance.

(3) Likewise, in case of college freshmen a decile rating may be used in predicting the student's most probable achievement (providing he studies) in various types of courses, in determining the most advisable study load to carry, in evaluating his excuses for failures, and in determining whether he shall be reinstated after failing, and in helping to determine his fitness for college.

(4) Another important value of an intelligence rating is its aid in bringing to the notice of the instructor, immediately upon entrance to the school, the student who is likely to make an exceptional record either by failing or by excelling. A certain percentage of failures can be avoided by advising the student that unless he works diligently his chances for passing are very slight. Failure on the part of a superior student may be avoided by an early effort to interest him in special lines of work and in independent study; for not infrequently he leaves college with the feeling that the work offered there is too superficial or formal either to meet his needs or to keep him busy.

(5) Tests are also used in special training and industrial schools. A fairly large percentage of boys and girls committed to reform institutions are mentally dull. Indeed, dullness is frequently associated with delinquency. The moron cannot distinguish between right and wrong sufficiently to refrain from engaging in petty criminal activities. Hence, measuring the intelligence of the inmates helps in choosing the proper educational program for them, and in giving them sympathetic care and discipline.

(6) Tests are being employed more and more in juvenile

courts. Obviously a bright lad of mischievous intentions should be treated differently from a moron offender who lacks a sense of responsibility.

(7) In its preparation of troops for participation in the World War, the United States supplemented its medical and personnel service with a psychological program. Before the armistice was signed a million and a half recruits had been given intelligence tests, the results from which were used in finding and discharging the mentally defective, in classifying men for different branches of the service and in hurriedly selecting men who would make officer and non-commissioned officer material.

(8) In large industrial plants where the labor turnover is sufficient to affect output, tests are frequently given in connection with other efficiency methods, in order to find positions for which the candidate is mentally qualified. If a job is too difficult on the one hand or too easy and monotonous on the other, the worker becomes dissatisfied, inefficient, and is inclined to leave.

Intelligence and Occupation. The relationship between mental age and occupation has been measured in several investigations, prominent among which was a study of men entering the army from different occupational groups during the World War. Letter ratings A, B, C and D were chosen to indicate different levels of intelligence. The average rating for unskilled laborers was C—, roughly representing a mental age of about 12. The ratings obtained by tradesmen such as horseshoers, bricklayers, painters, bakers, machinists, plumbers, carpenters and the like, averaged C, or slightly lower, indicating a mental age of approximately 13. Foremen, telegraphers and various kinds of clerks, army nurses and book-keepers averaged around C, with a median mental age of 15. Dental officers, mechanical draftsmen, accountants, civil engineers and medical officers fell in the B— class with an average mental age of 17. Officers in the engineer corps obtained the highest average rating, A, with the average mental age of 18.5. The mental age standard was set by the Stanford-Binet test in which the highest mental age given is 19, with 16 as the mental age of the average adult.

The following table shows the mean intelligence scores of the different occupational groups in a rubber tire plant.

TABLE IV

RELATION OF INTELLIGENCE SCORES TO OCCUPATIONAL GROUPS

Laboratory and drafting	147
Factory Council	144
General clerical workers	138
Shipping department	112
Factory committee	108
Foremen	88
Inspectors	86
Finishers and builders	87
Handing out stock	76
Truckers and mixers	47

These facts point to the practical value of testing procedures in business. By using methods of this sort critical scores may be found, a score above which means better than a one to one chance of being successful in a certain occupation, provided other factors such as lack of initiative and inadequate personality do not interfere. Conversely, scores below the critical point mean better than a one to one chance of failing.

Speed as a Factor in Intelligent Behavior. It is a commonplace observation that individuals who achieve the highest scores on intelligence tests or who reach the highest levels of intellectual attainment are the quickest thinkers. This has led to the belief that speed is an important element in intelligence. Accordingly, time limits are placed upon many of the intelligence tests under the assumption that time is a factor in the separation of the bright from the dull. Whether or not speed is to be considered an important feature of intelligent behavior depends entirely upon the definition of intelligence. Of course, if intelligence is defined in terms of rapid thinking, speed is an important aspect; on the other hand, speed measures other qualities in the individual aside from brilliance, for example, desire to surpass others and enthusiasm for the task. It is reasonable to suppose that a person who is slow under one set

of conditions might exhibit greater speed in a different situation. It cannot be said, therefore, to what extent speed signifies brilliance and to what extent it depends upon interest in intellectual achievement.

Spearman's Concept of Intelligence. Spearman[1] has probably done more than any other investigator, in recent years, in an effort to ascertain the exact nature of 'intelligence.' Briefly, his assumption is that an individual possesses a general intelligence or general factor of intelligence (G), together with a variety of specific factors (S's). The basis for this conclusion is the fact that when a large number of tests are intercorrelated, certain tests correlate much higher than others. In other words there is an apparent 'overlapping' of ability; certain of the tests seem to be measuring the same thing, certain of them different things. Spearman has attempted to answer the question, What are these things?

The intercorrelations merely show, however, that whatever set of causes explains the high correlations, as opposed to the low, is not as variable in the first case as in the second. Reading back into behavior and positing a common or general factor, such as general intelligence, in opposition to specific intelligences or factors, is pointless.

An Explanation of Spearman's 'G' and 'S.' Coghill's work on the embryo suggests an explanation of Spearman's 'G' and 'S.' Every form of behavior is a pattern-response the most obvious features of which are its specialized aspects, but the total pattern is always functioning. Hold out your hand and bend your wrist. The wrist motion is merely a local specialization or individuation of the whole act of holding out the arm. *Whatever the wrist is doing at any time is part of something the arm is doing.* In like manner, when a person is solving an arithmetic problem he is exhibiting a specialized intellectual performance comparable to the wrist movement. There is a total intellectual pattern from which the arithmetical reasoning individuates. This pattern is the insightful aspect of the individual's total mental life, and corresponds to what the arm is doing in the wrist illustration. This means that Spearman's 'S's' are not factors separate from 'G.' 'G' and 'S' are ab-

[1] Spearman, C., *The Abilities of Man,* New York: Macmillan, 1927.

stractions, and in reality, artifacts. When the wrist is bent we have an arm-act as much as a wrist-act. If the arm were moved without bending the wrist, the wrist would move also. The only difference between the two is differentiation of the arm movement itself in the one case and not in the other. In this sense, so-called 'special' abilities are merely differentiations of so-called 'general' ability.

The intercorrelations between certain tests are higher than for others only because the differentiations of insight with respect to certain problems have gone on at the expense of others. There is apparently no reason for believing that a person could not undergo the maturation processes necessary for equivalent scores in every test he took. It is well known that the brilliant individual is equally good in everything he does, all things considered. Lack of opportunity, interest, and proper stimulation should account for all exceptions. Ordinarily, tests that involve abstract reasoning correlate well with each other, such as tests in algebra and geometry. Range of information correlates fairly well with logical reasoning. On the other hand, tests that place a premium upon memory do not correlate as well with purely logical tests, and performances that are chiefly motor in character, such as aiming at a target, have, in the long run, very low correlations with logical reasoning.

Many 'intellectuals' are poor automobile drivers, for example. This does not mean, however, that they lack the 'ability.' It is merely that their energies are all organized about other sets of goals and were they to co-ordinate their muscles adequately a major re-organization of potentials in their nervous systems would be required. That this *could not be done,* as the concept *'lack of ability'* postulates, is again a pointless claim. There are, however, practical reasons why trying would be a waste of time. The 'intellectual' lacks interest in acquiring muscular skill; he lacks the patience, the self-confidence and the willingness to try it. He lives in a different world.

A similar situation obtains in case of the poor correlations between memory and logical reasoning. There are no facts available to show that a person with a poor memory *could not* acquire a good one, so that whenever he was tested for sheer

memory his score would be as high, relatively, as on a logical reasoning test. But the game is not worth the candle!

Returning to the main argument, 'specific abilities,' as measured by tests do not after all represent special 'capacities,' but merely the type of organization that happens to exist in the individual's total pattern of insight into situations in general. They represent products of interest, degrees of stimulation, and other factors associated with opportunity, and incentive, some of which date back to early periods in the individual's life.

The terms 'general ability' and 'general intelligence' should be abandoned in favor of 'level of maturation,' reached by the individual at the time he takes the tests. Then the correlations measure the degree of obviousness with which the whole conditions the activities of its parts. Where differentiation processes, required by the tests, are not permitted by the level of maturation already achieved, the test scores are low. Where the level permits complete differentiation, with respect to the imposed tasks, the test scores are uniformly high. Level of maturation represents amount of energy available for achievement. The higher the level the farther the differentiations can go, that is, the more 'intellectual' energy there is to be expended. This expenditure is the achievement itself.

Race as a Condition of Intelligence. A consideration of race as a condition of intelligence shows that social are inseparable from hereditary factors. If intelligence tests, standardized on American whites, were a fair instrument of measuring the intelligence of other races, Indians, Negroes, Italians, Portuguese, and so on, would be judged inferior. It is frequently assumed that, because only about 25 per cent of Negroes reach or exceed the average score for white individuals, Negroes would make no better showing if their economic and social status were equivalent to the 'whites.' As it is, the Indian, Negro and other races are inferior to white races only when intelligence is defined in terms of test-scores based on 'white' norms. There is no convincing evidence that one person's so-called intelligence is like another's, or that the intelligence of one race is qualitatively similar to the intelligence of another race. One individual will excel in many lines such as art, literature, business and science, while another individual

will exhibit superiority only in one line. So-called intelligence is therefore as inseparable from factors like temperament, interest and ambition as it is from training. Consequently, if intelligence is a thing in itself, it is necessary to concede several intelligences in the same individual.

Physical Condition and Intelligence. Average 'ability' is associated with average health and with a normally *differentiated* nervous system. No striking organic brain defects (although defects undoubtedly exist) have been found in morons, but as the lower stages of feeble-mindedness are reached definitely undifferentiated brain conditions can be observed. In the worst cases of imbecility and in nearly all idiots, brains are badly underdeveloped texturally; they may be small in size but not invariably. Occasionally the forehead slants back sharply from the eyebrows, giving to the individual an apelike appearance. Heads of small size are called *microcephalic. Hydrocephalis* is another abnormal organic condition characterized by an enlarged cranial chamber, caused by excessive amounts of cerebro-spinal fluid in the brain ventricles. This condition not only increases the size of the head but often presses the brain material into thin layers against the inside of the skull.

There are various glandular defects associated with feeble-mindedness. Thyroid and pituitary deficiencies, especially, are frequent contributing causes. Indeed, as a rule, the feeble-minded individual is also feeble physically, not only in one but in many respects. He possesses a weak heart, a lowered metabolism and weak muscles; he breaks down physically under strain. On the other hand, where general physical weakness is associated with intellectual superiority it is a weakness not of nervous and physical organization, but a special abnormality which does not disturb the behavior of the individual as an organic unit. The precocious child is in the long run superior both physically and mentally. This is to be expected, for generally speaking, those conditions which produce excellent physical development also produce a stable, well developed nervous system; conversely, those conditions which produce a defective nervous system bring about a defective set of bodily organs generally.

Emotional Blocking as a Condition of Intelligent Behavior. Emotional blocking hinders the development of intelligence. There are many cases in which the I.Q.'s of children have increased with the elimination of emotional maladjustments. It has been suggested that these children were innately more intelligent than the test indicated, and that removal of the blocking released a potential which had not hitherto expressed itself. But again the inference of a capacity or potential to explain the results of tests is inconsistent with scientific principles. Any performance is explained in terms of the condition under which it takes place. Many of the conditions of intelligent behavior are unknown, to be sure, but to classify these unknown conditions under the term capacity is merely to admit ignorance. Emotional blocking is, therefore, a definite condition of intelligence if the latter is defined as actual performance.

Pacing. Between the extremes of excessive over-stimulation and under-stimulation of the child lies moderate stimulation which, if properly controlled leads to a steady, normal development of intelligence. This mode of stimulation may be given the name, *pacing.*

Pacing is gradually giving the child more and more complex tasks to perform, as he grows and matures. The increase in stimulation and in difficulty of problems should not at any time be faster than the child's rate of maturation, otherwise repeated failures to master the tasks at hand are induced. Too frequent failures lead the child to develop undesirable habits of work and unhealthy emotional attitudes. Once he masters a task of a given difficulty he should not be presented with another and more difficult task until a recess period has elapsed during which he may have time to *grow* to the more difficult situation. *Theoretically* if the degree of stimulation is adequately controlled, *the child should be able perfectly and easily to solve each new problem the first time it is attacked.* When he must resort to 'trial and error' or to a random procedure it is evident that he is not ready for the problem and that the conditions under which he is being forced to learn are not adequately controlled.

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CHAPTER XI

THE DEVELOPMENT OF EMOTION AND WILL

Psychological Sources of Energy

The Sources of Energy in the Individual. It has long been recognized that the source of energy in the individual, on the mental side, is feeling and emotion. The human race has built around this idea a psychology of rewards and punishments under the assumption that satisfaction and annoyance are forces that control the learning process. On the physical side, the source of energy in the individual has long since been defined as instinct. And often, instinct and emotion have been regarded as the physical and the mental aspects, respectively, of the same ultimate source of action. More recently an attempt has been made to combine the meanings of instinct and emotion into a single concept, namely, drive, or urge. If we can make use of the organism's inborn drives or urges, so it is said, we can be successful in guiding its mental development.

These conceptions raise again the mechanistic issue. They make the unmanageable assumption that emotions, instincts, and drives are independent supplies of energy. In order to understand this difficulty, reflect again upon the character of a potential found anywhere in nature. The gravitational stress, representing the capacity of a body to perform work, is not inherent in the body itself, but is derived from its position in the system. Voltage is not inherent in the electric current; it depends upon a *differential of charges within an electrical field.* There is nothing absolute about a potential; one potential is always relative to another.

The Problem of Emotion and Instinct. Returning to the problem of emotion and instinct, there are modes of behavior which have been called emotion, like fear, anger and love. There are feelings that have been called satisfaction and

annoyance. There are activities like eating, drinking, sex responses, care of the young, fighting, and fleeing from danger, that have been called instincts or urges. It is not objectionable to use the terms feeling and emotion because they describe specific experiences upon which all observers can agree. But it is different with the terms urge and instinct. They are efforts to depict the dynamic aspects of behavior in language that begs problems vital to an understanding of human nature. They assume, for example, that we eat because of an urge to eat. The urge makes us eat and provides the energy; it demands its own expression under its own power. The way it is defined there is nothing about this urge that explains *why it demands expression, or tells us why the expression takes one form rather than another, or why the resulting action takes place in one direction rather than another.* It begs all these questions and is therefore an unsatisfactory concept. An independent, self-expressing 'urge' is a contradiction in terms, a fiction and a dynamic impossibility.

Volitional Character of Emotion. It would be more correct to say that a person possesses an urge because he eats than to say that he eats because he possesses an urge. Man is an energy system, whose existence depends upon eating, and the so-called urge is caused by the fact that the nervous system is disequilibrated by hunger contractions. The disequilibration *results in* the 'urge' or demand to eat. From the standpoint of experience, the most important aspect of the eating-behavior is desire for food; there are hunger pangs, but these are only a part of the total hunger-experience which always involves a desire for food. In turn the desire for food always includes the intent or will to eat. Thus, eating-behavior is *volitional.*

It is the same with feelings and emotions. They are primarily phenomena of the volitional life. Fear always involves the desire, intent and effort to escape; anger always involves the desire, intent and effort to resist. Often the intent and the effort are curbed; nevertheless, they are present. Feeling and emotion are no exceptions to the rule that behavior is purposive and always takes place with respect to a remote end. The volitional and emotive aspects of behavior, therefore, follow the same principles as those which we have been applying all along.

The Problem of Will. *The will is the energy of the total human system consciously conditioning the activities of its parts.* A person moves a hand, speaks, and walks just as a gravitational system 'moves' the apple when the stem breaks. In man a stimulus that disturbs the balance of his neuromuscular system corresponds to the breaking of the stem. The stimulus disturbs his whole system just as the breaking of the stem disturbs the whole gravitational system. Then the whole system is involved in the process of regaining the balance. It takes a 'whole' man to move an arm, to speak a word and to think a thought.

No action can be induced in a system of energy except as *it* is made to act as a whole upon *its own* parts. Try, for example, to change the position of a stone. It can be accomplished only as the whole system resists with *its own* forces the influence from outside. This fundamental principle applies to human beings. They are systems of energy. One cannot induce a person to move a hand, speak a word, think a thought except as one induces *him,* as a whole, to act upon the hand, the throat, or the thought. The medium through which action is obtained from a human being is the *will* of that human being. There is no other method. Whether the technique is called suggesting, persuading, demanding or forcing, it is all the same; it is an appeal to the will of the individual. The appeal is made, always, by setting up a tension toward a goal. A child will not respond under compulsion unless that compulsion *makes him want* to comply. The control of behavior has been effected *when wants have been induced and goals established.* But a want cannot be established without a goal or a goal without a want.

Origins of the Will. The first movements and the first consciousness of the infant are undifferentiated. Similarly with the volitional life of the infant. At first there is only the general desire to be active, and all desires that come later are individuations from this general desire. Expressed in the language of the nervous system there is at the outset an undeveloped field of nervous energy. Tensions raised by various kinds of stimulation demand resolution in mass action. There is no specific goal, yet there is a goal-situation. So far, be-

havior is purposeful only in a general way. Thus the child's desire to be active is an undifferentiated mass response to the numerous stimuli impinging upon the nervous system. The mass response reveals itself in squirming and kicking. Expressed in the language of intelligent behavior, this same energy-field exhibits its potential in the form of an undifferentiated curiosity relative to everything that is stimulating it. As the infant grows this curiosity differentiates into attitudes of questioning, eagerness to learn, to explore, to search, and to reach out. Behavior then becomes purposeful in more specific ways.

Sources of Stimulation. The volitional life of the organism, whether we call it will, or feeling, or emotion, depends upon stimulation. *There is no mode of self-expression that does not depend upon restraint, or something on which to act.* The restraint affects the organism by furnishing it stimulation. This stimulation comes from external environment and also from within the organism itself in various tissues that lie external to the nervous system. These tissues are the muscles, the digestive tract and the glands.

Much of the tension that develops in the organism is thus induced internally, and it becomes necessary to study a part of the nervous system not hitherto mentioned, namely, the *autonomic nervous system.* Over this channel comes the stimulation that gives to the organism its spontaneity of action and its emotional vigor.

Physiological Sources of Energy

The Autonomic Nervous System. Leading from the base of the brain over certain of the cranial nerves, and from various places along the spinal cord, are bundles of fibers that connect with small nerve centers in various parts of the body. From these centers, fibers ramify to the internal organs: muscles and linings of the digestive tract, and glands. Bundles of fibers of a similar kind connect also with the sweat glands of the skin, and with small arteries all over the body. These fibers are carried by motor nerves to the muscles.

The Sympathetic Division. This vast network of the autonomic system can be divided, conveniently, into three parts, the *sympathetic,* the *cranial* and *sacral* divisions. The sympathetic division supplies innervating fibers to the radiating muscles of the iris, dilating the pupil; it sends fibers to the heart which accelerate its action; relaxes the walls of the lower colon; contracts the muscles at the exit of the bladder; innervates small glands above the kidneys, known as adrenal glands, and excites both the external and internal musculature of the reproductive organs. It inhibits the muscles of the stomach and intestines; excites the liver; contracts the surface arteries and sweat glands; inhibits the salivary glands; innervates the tear glands and contracts small muscles behind the eye-balls, causing the eyes to bulge. It also dilates the nostrils and increases the action of the chest muscles in breathing. (See Fig. 27.)

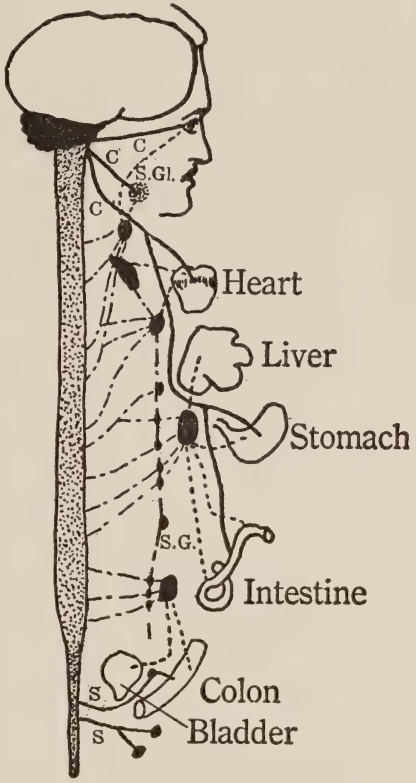

FIG. 27. DIAGRAM OF THE AUTONOMIC NERVOUS SYSTEM (greatly simplified).

C, C, C, fibers of the cranial division leading out from the medulla. S, S, sacral fibers to the organs of elimination. Dashed and dotted lines are sympathetic fibers. S. Gl., salivary glands; S. G., spinal ganglion (one of a chain of ganglia).

The Cranial Division. The cranial division originates in the base of the brain. It sends out motor fibers over the third cranial nerve to the constrictor muscles of the iris. Fibers over the seventh and ninth cranial nerves go to the salivary glands where they have an innervating effect. The main

part of this system, however, is composed of the vagus nerve (the 10th cranial). This nerve, which derives its name from the wandering nature of its branches, goes to the heart where its influence is inhibitory. It excites the glands and muscles of the digestive tract as far down as the lower colon. The cranial division also consists of sensory fibers conducting from sense organs in the linings of the digestive tract to the central nervous system.

The activities which the cranial division subserves have to do with the intake and conservation of energy of the body. The system prepares the digestive tract for food by maintaining a flow of digestive secretions. Through its innervating effect on muscles of the digestive tract, it aids in keeping nutritive material passing along the tract. It conserves the heart muscle by conditioning longer periods of rest between contractions.

The Sacral Division. Certain nerves (second, third and fourth sacral) lead from the lower end of the spinal cord to organs of the abdominal region. These nerves contract the walls of the colon; relax the sphincter muscle of the anus; relax the muscles at the exit of the bladder and exert an inhibiting effect upon the arteries and muscles of the reproductive organs, keeping them relaxed. In general this part of the system controls the evacuation of waste materials from the body and provides mechanisms for sensing the need of defecation and voiding.

Relation of the Sympathetic to the Cranial and Sacral Divisions. It is an interesting fact that two of these systems, the cranial and the sacral (known together as the *parasympathetic*) send fibers to the same structures of the body as are supplied by the sympathetic nerves, but their influence on these organs in each case is the opposite. The sympathetic division, during excitement and pain, pre-empts the use of certain of these organs and causes others to cease functioning. In short, it controls the output of that energy which accumulates under the influence of the parasympathetic system. The sympathetic system is an important factor in the redistribution of body energy during emotional excitement.

Action Induced by Hunger Stimulation: Richter. Ex-

periments by Richter [1] and others, on rats and human beings, show that bodily activity occurs in cycles or rhythms certain of which correspond to hunger cycles. Not long after the stomach becomes empty, the muscles of the stomach wall begin to contract. It seems evident that this contraction stimulates certain sense organs, thereby giving rise to the feeling of hunger. The instant the contractions begin, the animal becomes more active, and as the magnitude of the contractions increases, general activity increases. This heightened activity eventually takes the form of going to a known source of food, or of hunting for food. Much of learning and the development of insight that occur in animal behavior are concerned with differentiations of mass actions induced in part by hunger stimulation. The infant's first hunger activity is a relatively undifferentiated mass action, involving crying, kicking, and squirming. Maturation has already provided one differentiated aspect of this total pattern, namely, sucking.

Glandular Stimulation. Removal of the adrenal gland in animals renders them much less active and eventually ends in death. Body temperature and blood pressure decrease; muscular weakness sets in, followed by general emaciation. These glands, which are ductless, secrete a very powerful autocoid (adrenin or epinephrine); which, in very small amounts over the normal, induces profound changes in the organism. It inhibits the rhythmic contractions of intestinal muscle; brings about a discharge of glycogen, an organic sugar, from the liver, giving the muscles more energy; increases the blood pressure, and also increases the coagulability of the blood. The thyroid gland is another important internal regulator of the organism. An insufficiency of thyroid secretion brings on lessened activity and excessive secretion induces heightened activity.

Organic Stimulation During Exciting Emotion. If we paint the total picture of organic changes in man during exciting emotions (fear, anger, rage and pain), much evidence is found of internal stimulation.

First, digestive glands and muscles cease functioning; blood which ordinarily collects in large quantities about the

[1] Richter, C. P., "Animal Behavior and Internal Drives." *Quart. Rev. Biol.,* 1927, Vol. 2, No. 3, 307-343.

digestive tract while digestion is going on, shifts to the external muscles where its energy is available for use in heightened muscular activity.

Second, the liberation of stored animal starch from the liver into the bloodstream gives still more available energy to the external muscles.

Third, increased blood pressure and heart-action produce a more rapid circulation of blood through the organism, thus a more rapid washing from the muscles of those toxic substances that are given off during increased activity.

Fourth, increased breathing and relaxation of the bronchioles of the lungs means a more rapid absorption of oxygen and elimination of carbon dioxide.

Fifth, the greater coagulability of the blood protects the organism from excessive bleeding in case of injury. It is significant that pain and emotional excitement should be associated with this phenomenon of coagulation, for the times when the organism is excited or suffering pain are the times when the chances of injury are greatest.

Sixth, during heightened muscular activity the temperature of the body rises. Intense emotive behavior involves greatly increased muscular action; meanwhile, the sympathetic system excites the sweat glands and causes the organism to perspire. The effect of this is to prevent fever by reducing the temperature of the body.

To summarize, in emotive behavior, such as intense fear, anger and distress, there is an elaborate internal organic change upon which there is superimposed a vastly increased activity of the central nervous system and of the external muscles of the body. All this occurs in hurriedly seeking shelter from impending danger, in engaging in combat with a rival, and in fighting when cornered. Whatever the response, it is a complex performance in which all the organism's resources are being used in vigorous action with respect to a definite end.

Emotive Behavior in General

The Psychology of Emotion. In general, the source of emotive behavior is, as in all behavior, an undifferentiated total pattern. But this is not all. The pattern differentiates in part,

as we have just seen, through the influence of *internal* stimulation. It is this source of stimulation that, in part, makes the behavior volitional and emotive, but it is not, by any means, the only form of stimulation upon which emotive behavior depends. Emotive behavior is equally dependent upon a stimulus-pattern external to the organism, for all forms of behavior are responses to total situations. The internal stimulation gives to emotion its organic quality: the 'empty' feeling in intense fear and anger; the dry mouth; the cold chill; the awareness of the heart pounding, and the faster breathing; the bodily experiences of sexual emotion; and the heat and pressure of blushing.

In addition, there are the familiar facial expressions, gestures and postures characteristic of intense emotion, all constituting various ways in which tensions are resolved. These give rise to the feelings of intense strain and effort, through the medium of sense organs in the muscles themselves. Further, there must be a perception or imagination of the goal, an object or situation that, when reached, means the resolution of the tension. Thus, emotive behavior involves perception, imagination, and thinking, in terms of which the goal-situation or object is recognized and subsequently reached.

Emotion is not a special discrete kind of behavior. It is not something added to other activities. *It is an aspect of whatever the person is doing at the time, when, in the approach to a given goal, the tension is increased and maintained through intraorganic stimulation.* He may be driving his car and must suddenly avoid a collision; he may be climbing a mountain and, in dismay, find it difficult, for a moment, to maintain his balance; he may be working on a research problem and suddenly, with an intense thrill, grasp a striking solution; he may be learning golf and experience the joy of making a difficult drive; he may be trying to study and become angry when someone interrupts him; he may be listening to an orchestra, and be overcome with exultation; he may be arguing, excitedly, with a friend; he may be apprehending a clever joke; he may be watching, with consternation, his child cross the street in front of an approaching car. In all these situations, his behavior is social, intelligent, perceptual, and intentional. Emotive behavior, then, is any intentional, intelligent behavior, *energized.*

The Dynamics of Emotive Behavior. We have said that the will is the energy of the total organism conditioning the activities of its parts. But the will, in turn, is dependent upon disturbances in the form of stimuli that create differentials of potential in the nervous system. This means that there is no will when the nervous system is quiescent, or when there is no contact with environment. On the other hand, there is the greatest amount of volitional activity when the organism is under the greatest amount of stimulation. Some of the most powerful sources of stimulation are internal, just those sources that release the energy of emotion. In other words, much of the disequilibration of the nervous system upon which *will* depends is emotional. Witness the great vigor with which an enraged or frightened person fights or runs, and the added vigor exhibited toward a task from which one derives pleasure.

Dynamics of Anger and Fear: The Law of Increasing Energy. There is a corollary of the laws of least action and maximum work that, as we have seen before, explains why human beings exhibit more emotion at one time than at another. *This is the law of increasing energy, stating that the nearer an object to its remote end, the more kinetic energy it possesses, or the more work it will perform.* The energy results in work when an obstacle intervenes between an object and its remote end. Let a stone fall upon someone's head from the distance of an inch. It will strike with a slight thud, but will do no damage. It has gone only a short distance from its starting place, and as yet has relatively little kinetic energy. Now let it fall from a distance of a thousand feet. It is a different story. The potential energy of the stone, derived from its position in the gravitational system, has been changing into more and more kinetic energy, which means increasing momentum. Now the stone will perform work; indeed, enough kinetic energy will be expended against the object in its path to result in a fatality. In human life this law means that the nearer a person to a desired goal, the harder he will strive to reach it and the more he will resent any situation that thwarts him in his purpose. The resistance or resentment is exhibited in emotion, the human method of expending kinetic energy on thwarting situations.

The tired business man returns home for lunch, hungry, and finds that the meal has not been prepared and forthwith scolds the responsible party. The fisherman is angry when his mischievous small boy throws a stone into the pool just as a trout is about to strike. The driver becomes exasperated when his car breaks down on the way to an important engagement. A golfer, on the first tee, makes a poor stroke and his ball rolls into a gully. This is not so bad. But now he is approaching the 18th hole, bent upon finishing with a score below par. If he can drop the ball within a few feet of the cup his goal will have been reached. He is tense, eager, excited. But he tops the ball and it skims across the green into a sandpit on the other side. The player's keenness of disappointment, the anger vented upon the club, and the superfluous language, are all forms of kinetic energy expended upon the total situation that has intervened between him and his goal, when he was almost upon the goal.

Human beings are constantly near the goal of preserving their lives. Hence they always possess the kinetic energy necessary for self-protection. Let a mad dog jump at a pedestrian and the latter will run, dodge or fight with all his might. Witness the burst of energy with which one jumps from in front of a speeding automobile. No instinct is needed in situations like these! The human organism is merely obeying a familiar principle in dynamics.

From a practical standpoint, then, the existence of fear, anger, resentment, jealousy or any of the emotions involving intense unpleasantness is a sign that the individual's purposes are being thwarted, and that he is resisting. The only way to relieve the emotion, other than to let it be expended, is to remove the individual from his dynamic relation to the goal, which automatically eliminates the tension. This is not always easy, for interference will make matters worse if it is interpreted as an additional obstruction. For example, a child wants a toy that is in the possession of a playmate. He reaches for it but his playmate objects and forthwith he enters a tantrum of anger and jealousy. If the adult who intervenes is not tactful the tantrum will be exaggerated, for now the child feels that two people, instead of one, are keeping him from his goal. The way to handle the situation, of course, is to furnish the child

with a substitute goal. In every-day language this means to direct his 'attention' to something else.

Emotion and Insight. Emotion always involves an interpretation of the exciting cause. It depends upon perceiving one detail of a situation in relation to other details and is therefore an insightful response. To illustrate, a person is seen lying on the grass. So long as it is evident that he is asleep, the observer gives him but an indifferent glance. But let the position of the hand or an arm be suggestive of something wrong, and the observer approaches to investigate. He discovers that the body is cold and stiff. Instantly a sickening horror comes over him. Again, one could stand upon the edge of a precipice and look down with perfect composure if it were not for the thought that certain destruction would follow a misstep.

In handling emotional behavior, therefore, an appeal must be made to insight. This is the procedure in treating cases of personality maladjustments where the difficulty is traceable to misunderstanding, prejudice and undue suspicion. Inferiority complexes and other difficulties hinging upon poor social judgment can easily be eliminated if the sufferer can be induced to see his mistakes. But in treating such cases, much depends upon the personality and shrewdness of the advisor, and not a little upon a sense of humor that does not antagonize the sufferer. Little can be done until the advisor is familiar with the total situation in which the maladjusted personality is trying to maintain itself.

The Dynamics of Pleasure. Thwarting situations suddenly increase tensions and produce varieties of fear and anger. Conversely, sudden release from strain is expressed in a form of behavior intensified in proportion to the pre-existing strain. But now we have the opposite type of emotion, namely, pleasure or joy. It represents the intensified rush of energy that comes when obstacles are suddenly removed from the path of an object already under dynamic stress toward a goal. A listener is waiting, under the strain of expectation, for the point of a joke. The purpose of the story is to build up this tension and to release it suddenly. When the release comes the rush of energy is expressed in amusement and laughter. During a football game the home crowd is becoming more and more tense as one

unfavorable break in the game follows another. Unexpectedly, an opening by the home team is discovered and a player dashes through with the ball. The crowd scrambles to its feet, shouts, cheers, and waves.

Emotive Behavior and the Law of Least Action. Emotive behavior follows the law of least action, for it is not something different from intelligent behavior or learning. It is either one of these intensified, sometimes to the point of diminishing returns, where stimulation is so intense that the emotional aspects of the response reduce it to a primitive, undifferentiated, and therefore, unco-ordinated condition. This happens in stage fright, or when a person becomes so angry or jealous that he is temporarily 'paralyzed.' In cases of this sort, all the energy of the organism is raised to approximately the *same* high potential, and *the lack of differential results in inaction.* This is no exception to the law of least action, however, for it is a case of widespread tensions escaping to all the musculature of the body over the most direct routes. Under ordinary conditions, this escape directs the organism toward a definite goal.

Emotive Behavior and the Law of Maximum Work. No system of energy can be disintegrated except through the application of force. The instant the force is applied the system resists in accordance with the law of maximum work. Recall that one must exert effort to change the position of a stone, for the reason that the object is in balance with a gravitational system, and work is required to disturb the balance. It is no more striking in principle that a living organism should resist destruction since it is a complicated organization of energy. Defense reactions, such as fear and anger, are precisely those expenditures of energy on the part of the total organism that any outside force must overcome if it is to disturb the balance of the organism's energy and to destroy its unity. In turn, the organism, like any system of energy, undergoes disintegration in proportion to the energy it expends in resisting outside disturbances. Thus, after expressing fear and anger the organism is exhausted, that is, partially disintegrated. But it recovers through a building up process that is akin to a phase of growth. In the emotional behavior of the organism, therefore, being

aware of danger or of a thwarting obstacle, feeling the need of protection, making an effort to escape or to overcome the obstruction, are all psychological properties of the human energy-pattern, engaged in the process of resisting destruction. In the nervous system and muscles, there is an enormous amount of this energy available for resistance. The autonomic nervous system distributes this energy and makes more of it available when the organism is highly stimulated, as in case of pain, danger and excitement.

Later, when personality is the subject of discussion it will be seen how potent and varied are the ways in which an individual fights to preserve the integrity or balance of his personality. The resentment and desire for revenge after having one's feelings hurt, inferiority complexes, rationalizations, overdominance, excess shyness, suspicion, and paranoid attitudes of persecution and grandeur, are all various ways in which the personality reacts to social situations that it interprets as harmful to its existence.

Emotive Behavior in the Developing Child

Beginnings of Emotive Behavior. The importance of emotion in the life of the developing child cannot be overestimated, but its emotional life cannot be understood until the world of the child is understood, for the child's emotions depend upon his limited intelligence. Fear and anger are the first emotions to appear in infancy. Situations that threaten the infant's security, such as dropping him suddenly through space, can be understood, and produce fear. Sudden jars, loud sounds and any situation that produces intense pain also induces fear. The fear is expressed in squirming and making certain cries. Situations that restrict the infant's movements produce anger. Nearly as early as the appearance of anger and fear are the appearances of satisfaction, pleasure or some other form of enjoyment. These feelings are induced by situations which relieve strain.

So-called Conditioned Emotions: Watson and Rayner. Much has been said in recent years about the conditioning of emotional responses, especially by members of the conditioned

reflex school. Many experiments have been tried on children,[2] by the conditioned reflex method, in an effort to study the manner in which emotional life in the child is 'built up.' For example, a year-old baby is placed in a pen. It is presented with various objects of which adults are afraid, such as snakes and rats. These experiments prove that there are no inborn fears of animals and hideous objects. Only those situations produce fear which bring pain or discomfort, such as sudden jolts and jars, just those situations which the infant can understand in his own way are injurious. This means that fear depends upon a primitive level of insight. A snake is not feared, for it is not known that snakes are harmful and there is no tradition on the part of the child that snakes are loathsome. He picks up the snake and brings it close to his face with no misgivings whatever. He lets a rat crawl over him and is delighted.

In order to ascertain whether fear of these animals can be conditioned, the experimenter shoots a gun or claps cymbals together just as the animal is being presented to the child. Occasionally, if this procedure is repeated a sufficient number of times, the child begins to show fear of the animal when the loud sound is not included in the stimulation. But sometimes the experiment fails. The child becomes accustomed to the sound and laughs the more. Obviously, he will not develop a fear of the snake or the rat unless he thinks that the snake or the rat is producing the discomforting noise, or in his own way comes to the conclusion that the snake or the rat *mean* the appearance of the shock. Unless the one is perceived in relation to the other, there is no conditioning. It all depends upon what interpretation the child places upon the situation; that is, upon how he perceives it as a whole.

A Case of Conditioned Fear. *The easiest way to condition fears in young children is to let them observe the emotional reactions of their parents.* They are constantly placing the same interpretation upon situations as do their parents. The following is a typical case. Jane, three years old, was playing in the kitchen while her mother was cleaning lettuce in the sink. The mother had developed an aversion for snails and suddenly

[2] Watson, J. B., and Rayner, R., "Conditioned Emotional Reactions." *J. Exper. Psy.*, 1920, Vol. 3, 1-14.

found one in her hand. She screamed, dropped the lettuce and exclaimed, "Oh, the horrid snail!" The child did not know what a snail was, but could understand that her mother was terribly frightened. Jane had many occasions, thereafter, to hear about snails and how 'awful' they were. Naturally something that her mother was afraid of must be a dangerous object. Before Jane knew what they were, she was afraid of them; she developed her mother's aversion and retained it throughout her life.

Children develop fear of the dark, of animals, ghosts and 'bogie men' through the influence of foolish adults who appeal to their lack of insight and to their imagination in trying to discipline or tease them. The tone of voice affected when the parent wishes to keep her child out of the closet by saying, "Oooh, don't go in there, a bogie man will jump out at you," which the innocent child accepts seriously, produces the fear *merely because the child believes the parent.* The aggressive child who investigates for himself and does not rely upon his parent's deception, does not develop the fear. In any event, there is no mechanical conditioning of emotion, and the moral of this account should be obvious!

A Case of Aversion. The following incident illustrates the development of aversion and hate in children.

Walter, about nine years of age and of average intelligence, had been ridiculed by his father for being stupid. He had been bringing his readers home, proud of his achievement and anxious to read to his parents. But he was not making the progress that his father thought he should, and the latter evidently tried to spur him on. The father was more stupid than the boy! After being laughed at a few times for his mispronunciations, Walter refused to read to his father. Then the father became more overbearing, and, as a consequence, the boy stopped bringing his readers home. That his son should in this way be showing less interest in his school infuriated the father, who did not hesitate to make his feeling evident. Then the teacher reported that Walter was doing poorly in school; he was restless and listless in the classroom and spent a considerable share of his time in daydreaming. Not long after that, he began to evade school, and when the father learned of

his son's truancy, he whipped him. By now the lad hated school and everything in connection with it. He had become morose, deceitful and unco-operative.

Matters would have gone from bad to worse, had it not been for the principal, who, with a personal interest in the case, and with the boy's side of the story at her command, effected an understanding between the boy and the father through the mother, whose admonitions the father had hitherto ignored.

Spreading Effect in Emotion. Emotional reactions spread through a growth and expansion process. Moreover, emotion is a total behavior-pattern, a temporary or permanent mood that, under the law of determined action, colors the perceptions of concrete objects and situations with the feeling tone of the mood, and modifies the person's attitudes in the execution of specific tasks. Rebellious, the boy whose case has just been described, hated first to read to his father. However, he was responding not to his father alone, but to a total situation. He could not hate reading to his father without reading less enthusiastically to his mother. As his father became more unreasonable and his own distress more intense, the aversion spread to reading in any situation; then to other subjects in school; then to the school surroundings. His lack of interest in school involved his relations with his playmates, for, again the total situation is involved. He was losing the interests he had in common with his associates and, as a consequence, he became less spontaneous and happy in his attitude toward them. He was beginning to shut himself off from his social environment, and a vicious circle would have been the consequence, for every action demands a reaction. With less interest in others, others would show less interest in him. This condition would have aggravated his seclusiveness, which in turn would have aggravated the coldness of attitude on the part of those around him. Emotional life frequently becomes exaggerated in this way, commencing in an incident, which by itself would have been harmless enough, had it not started a series of responses that gained momentum with each added stimulation. The momentum is not caused by repetition of stimulation, as such, but by stimulation *from an increasingly complex situation.* The value of a stimulus depends upon the organization of

stresses within the individual, not upon repetition of response. The schoolroom would ordinarily have elicited pleasurable reactions in Walter's case. It elicited unpleasant reactions when the emotional background upon which the stimuli were to take effect was unpleasant.

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CHAPTER XII

THE DEVELOPING PERSONALITY

Early Development of Personality

The Origin of Personality. It is generally supposed that personality is determined by the acquisition of discrete and separate emotional responses such as fear, shyness, boldness, and hostility, and by the acquisition of specific social habits, such as obedience, co-operativeness, and honesty. But remember how the body is formed. Just as cells and organs develop under the laws of a differentiating, expanding and unitary field of physiological energy, with cells and organs the secondary factors, so, emotions and habits develop under the laws of a differentiating, expanding and unitary behavior-pattern, the personality. Personality is primary; emotions and habits are secondary, for they will develop or not develop, become 'fixed' or not, in accordance with the laws of balance that pertain to the personality-as-a-whole. *Personality is the psychological organism, and the laws of its development are the same as those for the physiological organism.*

At first, the physiological organism is a simple, relatively undifferentiated structure. Biologically, it is nondescript. Personality, at first, is the simple, undifferentiated, but total behavior-pattern of the individual. There is little that can be said about it because it, too, is nondescript. Phrases like general vitality, disposition to be active or sluggish, and words like docile or aggressive, stubborn, phlegmatic, or irritable, describe the situation accurately and completely. Nondescript as it is, however, the original personality gives direction to the growth processes that are to take place throughout the life of the individual. The personality begins in infancy and it remains the same personality with respect to many major characteristics, to the time of death.

General Background of the Personality. The psychological organism is largely a product of society. It must be understood, of course, that matters of physical health and the chemistry of the body are the physiological ground upon which the personality-pattern must rest. Even so, factors that are traceable to social environment are likely to be responsible for this physiological ground. Parents, whether ignorant and neglectful, or intelligent and careful, are responsible for the health of the nervous system through the food, air, and temperature conditions which they impose upon the growing child.

It is known that undue emotional stress affects the glands and other tissues of the body. An unhappy love affair, an economic disaster, a religious upheaval, or a series of tragedies in the family, may ruin the person's digestion, bring on functional heart trouble or diabetes, produce hyperthyroidism and an unbalanced physiological organism generally, all of which is reflected in the personality. But, given a physical constitution of normal vitality, together with a well-balanced social environment, and the individual will ordinarily survive such crises with no serious maladjustment. By far, then, the largest factors that control the personality of the physically normal individual *are social.* These social factors begin to operate at the instant of birth.

Personality in the Infant. The first differentiations of the personality are induced by the manner in which the infant is handled. This includes the routine of eating and sleeping habits that are required of him at the outset. Intemperance, either in giving the infant his own way, or in permitting him no freedom, begins to exert its effect at once. Aggressiveness, rooted in a desire to be active, develops at once into obstinacy if the child is fondled whenever he cries. The infant will develop stubbornness the first week of his life.

The character of the stimulus-patterns that surround the infant is of profound importance for the development of personality. It has already been noted how the infant perceives his mother's face as a whole and distinguishes it from other faces before he learns the existence of eyes, nose, mouth and ears, except as isolated objects to touch or pull. This face has a character of its own that may be friendliness, or sternness. It

is the same with the pattern of bodily feeling induced when the infant is handled. Before he can tell where he is touched, or before he knows that his feet are his own, the 'total feel' of his mother's touch can be distinguished from the 'total feel' produced when another person takes him. Gentle handling that results in no undue strain in different parts of the body, *versus* handling that is jerky, rough and uncomfortable, produce different patterns of tension in the nervous system and, as a consequence, different types of response on the part of the infant.

Confusion, racket, loud speaking, sudden changes in temperature, the tone of voice with which the infant is addressed, are not recognized, as such, by the infant, but are responded to unanalytically as total situations. There have been cases of serious nervous disorders induced in infants by too much noise, confusion, and rough handling. An obstreperous brother, although only three years of age, sent his baby sister to the hospital for several weeks as a consequence of playing with her too vigorously. The infant developed a case of hyper-tension that had affected her digestion and sleep until she was practically dead from exhaustion and malnourishment. Since the general character of the total stimulus-pattern in the environment of the infant reflects the personalities of those around him, it is but a short time before these personalities are reflected in the child. Nervousness, stubbornness, irritability, co-operativeness, gentleness, sweetness of disposition, orderliness of behavior, are in this way passed on, a social heritage. Personalities determine (in the most subtle but the most certain ways) the rate, intensity and quality of the stimulation which the infant receives.

Personality in the Growing Child. Authority that is arbitrary and persistent gives the growing child no opportunity to recognize initiative in himself, and if he does not eventually revolt against the restraint, he becomes dependent upon the aggressiveness of others and must forever play the rôle, in social life, of servant. On the other hand, if parents attempt no discipline whatever, the child may become dependent upon the docility and submission of others. Unable to understand restraint, when he finds it in the world about him later on, he must forever play the rôle of master. Innumerable instances of this sort could be cited that prove how, each step in the de-

velopment of the child, personality is formed by the character of those around him.

Dependence of Normal Personality upon Balance in the Human Nature Around It. Normality in the individual, then, depends upon normality in the *distribution* of human traits around him. The balance of his personality depends upon the balance of pains and pleasures which he receives at the hands of others. This balance must exist among the various levels of the human nature-pattern. In order to play normally with children, he must have an opportunity to express himself and he must meet with restraints. Either extreme of attitude toward him leads to selfishness on his part. In his relations with adults, there must likewise be a balance of opportunity to express himself and to learn adjustment to restraint. He must meet with sternness and leniency, gentleness and harshness, the delicate and the robust. In order to develop sympathy he must observe it in others; in order to fight hardships, he must meet them. As many children are spoiled by 'soft pedagogy' as by intemperate authority; as many by pity as by the lack of it; as many by praise as by blame; as many by the philosophy that permits too much freedom as by the philosophy that gives the child no credit for intelligence.

Freedom *versus* Restraint. The philosophy of 'soft pedagogy' makes the fundamental error of overlooking the laws of dynamics, which show that personality is the expression of an energy system. This is because self-expression always rests upon a *demand* under the law of action and reaction. *The individual exercises his freedom under laws of restraint.* Nothing happens in nature until it is forced to. The personality will not express itself spontaneously unless required by a situation that it can resist. Trouble comes only when the demands are not sufficiently varied from the child's point of view. Wants are based as much upon their lack of fulfillment as upon their fulfillment. If a person *always* obtained what he wanted he would cease wanting as quickly as if no want were ever satisfied. Too much sympathy, and too much indifference lead to the same end, a hate of human life. Initiative depends as much upon inhibition as upon the reaching of goals.

Personality must have hardships, something from which to

rebound, but when resistance is too great or too slight, inaction of the personality is the consequence. Evidence of this basic truth is found in the fact that children *who always have their own way, deliberately make trouble in order to meet with restraint.* This is one of the reasons for the unruliness of the pampered child. On the other hand, the child who is constantly abused fights desperately for his own initiative.

The Projection of Parents' Ambitions on Their Children. We have said that normal personality depends upon a balance of freedom and restraint. Oftentimes, lives are spoiled by a type of restraint that is not apparent to the person who furnishes it. A typical instance is found in the projection of parents' ambitions upon their children. The memories of the adult are frequently replete with thoughts of their childhood, of wishes not fulfilled, or thwarted ambitions, of opportunities for which they craved, but were denied. It is natural that they should desire for their children more opportunity than they themselves enjoyed. This desire is not alone altruistic. It is selfish, because adults demand the pleasure of seeing their children accomplish what they, themselves, were denied. Unwittingly this generosity is sometimes nothing more than a projection of their own unfulfilled ambitions on their children; they are now *re-living their lives in their offspring;* they are seizing a long delayed opportunity for their own self-expression. Then difficulties arise when their own ambition for their children does not coincide with the aptitudes and desires of the children themselves.

Frequently, also, a mother, unhappy with the father, turns to a small son for companionship, and demands from him the confidences and adult types of response which she is not receiving from the father. Conversely, the father may turn to a daughter for similar compensation. Such expedients not only aggravate family discord, but place altogether too much strain upon the personality of the child.

The Dynamics of Personality

Nature's Guarding of Remote Ends. *The laws of energy harmonize completely with the principle of idealism in human*

life. An ideal is a goal for which to strive, but always beyond reach. The ultimate remote ends of falling bodies, electrical currents, and currents of water, are forever beyond reach. Nature does not 'permit' her ultimate goals to be attained. If a gravitational system were so constructed that falling bodies could reach the center of the earth, it would not be a gravitational system. It would be an open field so thin in character (lacking in density) that there would be no gravitation. When a low pressure area occurs in an atmospheric field and air currents rush in, the goal is only temporary; if the newly arrived air were destined to remain there forever, it would mean that the entire system had become static. Permanent equilibrium in nature means inactivity; in human beings it means death.

Thus it is that *idealism in human life conforms to natural law.* It is more than a moral precept. The child who has no goal ahead toward which he is striving soon ceases to be human; and there must always be a goal beyond reach. Subordinate, however, to the major goals of life, there must be minor ones, which, like the temporary low pressure areas in the dynamic field of the atmosphere, *can be attained.* Whole races flounder with no definite goal for their civilization to reach. Once society loses its idealism, it disintegrates. This fact is true for social institutions like fraternal organizations, the church, and the state. They die unless there is something vital to struggle for. In periods of prosperity large masses of people become morally lethargic; the social group loses the strength of its 'personality'; its culture degenerates. *Anywhere, in terms of dynamics, the absence of goals means the absence of potential and this means incapacity for action.*

The Growth Potential and Its Consequences. At this point in our discussion, we should be reminded that the individual makes an important contribution to his own development, in spite of the fact that he is dependent for his personality upon the human nature around him. This contribution comes from the growth potential in the individual, which gives to his behavior spontaneity, a searching character, aggressiveness, and creativeness. *An explanation of personality requires two reference points, the social group and the individual.* Without both at the same time, there is neither the one nor the

other. If the individual were passive, no amount of social influence would create a personality; with the group passive, no amount of effort on the part of the individual would result in growth. Where one situation influences another, the objects acted upon are always *active*. This means that, in the end, without a social environment there is no growth potential to be expressed in personality. Personality comes into existence in the individual in accordance with the law of derived properties, with society the whole from which the part derives its human character.

Personality and the Law of Field Genesis. Personality is an expanding and differentiating total behavior-pattern of the individual; it is a growth unit. This is another way of saying that specific traits develop in the process of maintaining balance, harmony, and order in the total personality as it differentiates.

This personality comes into conflict with its environment, especially with group standards of living. The child has everything to learn and the development of personality is a learning process, taking place on a large scale. His conflicts with his social environment, therefore, are many. There are desires for possession, play, and, later on, desires concerned with sex life, all of which must be put under social control. There is a will that must be trained; there are goals that must be postponed. All of this keeps the individual under tension. Ordinarily he is able to resolve these tensions adequately; he compensates; he diverts uncivilized tensions into acceptable creative activity. However, if taboos are too frequent and restraints too prolonged, the conflict between the individual and the social group becomes severe. The individual finds himself repressed; he will shun the harsh and cruel world; he will construct alibis in order to justify his conduct. Like the dammed-up stream, he will seek outlets around any obstructions that stand between him and a goal.

Personality and the Law of Maximum Work. The personality will fight for its existence. A single wish left unfulfilled disturbs the entire behavior-pattern and threatens its existence in proportion to the disturbance. Then the energies of the whole organism are brought into play in a process of re-estab-

lishing the balance. One rises to his own defense, often anticipating situations that may disturb him. The ways in which the personality resists disintegration are legion. It will compensate, rationalize, become introverted, sublimate and regress, in the course of retaining its *status quo*. Each is a type of tension-resolving process.

Methods of Maintaining Unity in the Personality: Compensation. A certain professor is always inviting criticism from his students. If he actually obtains what he requests, he becomes very much distressed, for it is flattery he is seeking instead of criticism. By his apparent desire for criticism he is compensating for an egotism which he finds unpleasant in the light of social standards. His tension toward this goal is not resolved. Social disapproval prevents him from resolving it directly. He cannot boast and call attention to his achievements, so he attempts to resolve the tension indirectly by inviting criticism in the hope of securing praise. His behavior is a form of compensation because it reduces the tension under which he is living. His manner of questioning shields his egotism from the eyes of the social group. His inviting of criticism is nothing but a pose, proved by his distress when he obtains that for which he asks.

A child becomes a bully; he teases younger comrades and boasts about how well he could 'lick' the entire neighborhood, but he turns out a coward when his bluff is challenged. His boastful attitudes are compensations for his feeling of cowardice; they give him a sense of security, for he believes that his associates are regarding him with awe.

Introversion. Introversion is another tension-resolving process involving numerous modes of behavior. The individual finds it too difficult to resolve his tensions objectively by making straightforward responses to his fellow beings. He would like to fight those who are apparently abusing him, but he is afraid; he longs for greatness, but he knows that he 'lacks the ability.' Life is a round of disappointments, hurt feelings and inadequate responses from others. There is an indirect route out of the difficulty, an easier one for him, since his potentials are not strong enough for external goals. He sets up goals in his imagination and reaches them in his daydreams.

He 'flees from reality'; he becomes introverted. In his daydreams, he is the hero he would like to be in actual life; he assassinates his enemies and derives the thrill of which society deprives him; he wins his battles and preserves his self-respect. His personality finds its balance in the world of imagination.

Unless carried to an extreme such behavior is normal and desirable. For many there are whose ambitions cannot be fulfilled as fast as they are conceived. Meanwhile they are achieved in daydreams, and in daydreams, also, plans are constructed and inventions created. Indeed, the person who does no daydreaming is unlikely to rise about the level of mediocrity. The danger of deriving one's pleasures in life solely from imagination lies in the eventual loss of courage to fight for achievements in the world of reality. In children, extreme daydreaming is a sign of a maladjusted personality. Such introverting may lead to a confusion between the world of reality and the imaginary world, to pathological lying, or at least to persistent habits of exaggeration. Carried to an extreme in unstable individuals it may become a form of *paranoia* in which the patient has delusions of grandeur or persecution.

The dreamer is always the hero in his daydreams. He may be the conquering type of hero who pictures himself a general in battle, a star on the football field, a winner in debate, or the president of his country. He may also be a suffering hero, indulging in self-pity. Everyday occurrences of the suffering hero form of behavior are found in pouting, sullenness, and in refusals to eat and play. Such attitudes can best be handled by ignoring them. If the child who refuses his dinner finds that no one cares, he will eventually manifest all the symptoms of genuine hunger. In exaggerated and abnormal forms the same behavior is found in delusions of persecution, acts of martyrdom, in the simulation of illness and even in suicide.

Identification. Identification is a form of introversion either of the conquering or the suffering hero type in which the individual plays the rôle of a personality about whom he has read or heard. Harmless and normal cases are found in a child's play activities in which he imagines himself a doctor, a priest, a detective or an adventurer. But it is a different story when a young boy runs away from home and aspires to be

'Al' Capone. Dime novels and moving pictures sometimes induce behavior of this sort, especially in the child who is unhappy at home.

Rationalization. Rationalization is one of the most common of all tension-resolving processes. A person carelessly bangs his head against a door that is standing ajar. He becomes angry at the door and kicks it shut as if to punish it for hitting him. It is unpleasant and difficult to admit carelessness. To admit blame is to assume that one's judgment was at fault and needs to be improved. This means a change of the *status quo,* but an energy system resists changes in *status quo.* Other things being equal, therefore, the personality will not admit the blame; the most direct expression of the blaming process is one which preserves the old self-respect. The resentment at being hurt is kinetic energy which must perform work in the line of least action. The most available and relevant target is the door or perhaps the person who left it ajar. Blaming the door preserves the integrity of the 'ego'; then the 'ego' need not suffer the unpleasantness of self-criticism.

Multiple Personality. In highly sensitive, unstable individuals, the fight against the disequilibrating influences of unbalanced demands from society may end in apparent disunity. Then there develops what is known as a divided personality. *S* was a case of this sort, described by Dr. Morton Prince.[1] In her early life *S* had apparently been subjected to prolonged emotional strain. Too many desires organized about her main goal remained unfulfilled. Because she was nervously unstable to begin with, one personality after another developed as she sought the outlets her tensions demanded. *Apparent disunity was her way of preserving unity.* For years she was not allowed the freedom and dominance over others which every normal person requires. Her social environment did not permit it. This goal of dominance was reached in a second personality, *B,* who could successfully exert authority over *S*. *S* and *B* were not segregated completely, for *B* was able at will to change herself into *S,* but *S* knew nothing of *B*. The patient was a single personality, but had split into exaggerated systems of opposed

[1] Prince, Morton, *The Dissociation of a Personality.* New York: Longmans, 1916.

traits which individuated and expanded in a relatively segregated fashion, all in the course of maintaining organization in the total individual.

The *S*-personality was amiable, tractable, generous, interested in other people and fond of children. *B,* however, was ill-tempered, revengeful, mean, tricky, unco-operative and selfish. At unpredictable times *S* would enter into a prolonged period from which she would recover with no memory of what, meanwhile, had occurred. This period was the time when she was exhibiting the *B*-personality. *S* might be standing before a mirror, combing her hair, preparatory to going out. She would suddenly lapse into *B,* who, realizing that *S* had combed her hair in a particular fashion because she especially liked it, would take it down, arrange it in a most unbecoming way and change herself back into *S*. *S* would find herself late for her engagement and with her hair arranged in an outlandish fashion, unable to recall that, in reality, she had done it herself.

One time *S* knitted a baby blanket for a friend. *B* discovered and unravelled it. At another time *B* boarded a street-car with only five cents in her pocket, rode to the end of the line, got off, and changed herself into *S*. *S* found herself in the outlying districts of the town, the street-car disappearing out of sight, forced to walk back. Doctor Prince's problem was to inform *S* about *B,* and to construct a personality with attitudes, feelings and ideas comprehensive and broad enough to include the compatible features of *S* and *B*. This he succeeded in doing, eventually, with the aid of hypnosis. *He expanded her personality and re-differentiated it in such a way that its parts became related in a normal fashion.*

Characteristics of the Child's Personality

The laws of personality development have been discussed, and the various forms of behavior described, that are commonly found in efforts of the personality to maintain its balance. The next problem is to review the major characteristics of the child's personality. These are the traits which he must modify, and adjust to the demands of his social environment, both of other children and of adults.

Selfishness in Childhood. First, the child is *selfish.* He has no conception of property rights or of the duties of others that require *their* time and energy. The world exists for him only. For him there is no difference between toys that are given him, as his, and the toys that belong to his brothers and sisters. His wants are many and there are for him no reasons why he should not possess anything he desires. Accordingly, he appropriates objects and executes acts regardless of anyone else in the world. His environment, whether it includes an expensive toy, a priceless rug, his mother's dress or his father's glasses, is something to investigate; these objects are his, if he wants them.

Unmorality of the Child. Second, the child is *unmoral.* There is no inborn idea of right and wrong, no native modesty, nothing pure or impure, expensive or inexpensive, no remorse, no conscience; there are no abstract values, no principles as guides to conduct except his own desires. By implication his philosophy of life in these respects is pure utilitarianism and pragmatism. The abstract reasoning of an adult makes no appeal to him; taboos and principles are at first unintelligible.

Immediacy of Goals. Third, *the child's goals are all immediate.* He lives in the present. What he wants, he wants *now;* postponement is a mystery. There is no reason why there should be only three meals a day; there is no reason why he should not eat when he is hungry. There is no foresight for there is no tomorrow to provide for. There is no conception of time, beyond an undifferentiated idea of duration.

Egotism in Children. Fourth, the child is *egotistical* and proud of possession and achievement. The child's *self* plays a large part in his world, especially after he learns which objects in his environment belong to him and which to his family. He is forever volunteering to his playmates that *he* has a new cart, a new pistol, a new pair of shoes. *His* possessions are always the best and his father is stronger and more clever than anyone else's father; his house is the best, and no one's dog is as good as his. Many are the quarrels that follow such claims when a group of children gather together and compare notes.

Suggestibility and Credulity. Fifth, the child is highly *suggestible* and *credulous*. He is a follower. This can be traced to his lack of knowledge and to the undifferentiated state of his thinking. Under these conditions, a suggestion will produce a positive response. The child seldom questions anything except when it fails to harmonize with his egotism and pride. His experience lacks 'ground' with which to resist suggestion. Credulity is based, also, upon an eagerness to learn.

Margaret, of better than average intelligence, had been invited to a party in the neighborhood. It happened that the young hostess, with whom she was to walk home after school, was late in leaving the schoolroom. Meanwhile Margaret was talking with two other little girls in the schoolyard. One of them said to her, "Come on, do not pay any attention to her (referring to the young hostess); you don't want to go to the party." *She didn't go.* Needless to say, the parents concerned were much more embarrassed than the children. Margaret did not understand why she *should* attend the party, if she did not want to, although she had dressed for it, and had been invited for several days. Nor was the young hostess in the least disturbed.

At another time Margaret went to the store, a dime in her pocket, with which to purchase paste for her school work. She was accompanied by two small friends who, upon their arrival at the store, suggested that Margaret buy 'suckers' instead of paste. *And she did.* When questioned by her parents she was astonished to be told it was an error. "Why, they told me to!" she admonished.

Negativism. Sixth, the child is strongly *negativistic* toward suggestions or demands that do not aid him in resolving his own tensions, or that deprive him of chances for initiative. If it is suggested, at the table, that 'he will be sure to like' a new dish, he will generally disdain it. Let an adult extend his hand in greeting to a small boy, and the latter will likely move away, with his hand behind his back. Tell a child not to step in a pool of water and he will approach as near to the edge as he can. Tell him that he must *not* put on a certain pair of shoes and he will discover that *this is exactly the pair he wanted to put on.* All this is the natural, dynamic response to restraint,

and is almost certain to occur unless reasons to the contrary are given that fit the child's own standards of living.

Lack of Tradition and Prejudice. Seventh, the child has *no inhibitions and traditions,* religious, racial, or social. There are no prejudices, aversions, or discriminations, except in relation to people whom he regards as strangers, and therefore persons of whom to be suspicious. Children of all races are alike to him, one as good as another. It is a great shock to learn that he is 'different' from those whom he has treated as an equal and from those whom he expects to treat him as an equal. A Jewish boy, for example, suffers his first pang of inferiority when a little red-headed Irish boy, seated in front of him in school, turns around, sticks out his tongue and whispers, "Sheeny." He returns home and asks his parents if he is really any different from his comrades. It is a shock to a white child when first told that she must not play with Sally because Sally is colored. It is a complete puzzle to the small son of a millionaire who is told by his father that he cannot bring Don home with him because Don's father is a laborer.

Lack of Affectation: Honesty. Eighth, the child is *natural, unaffected, honest, trusting,* and takes everything for granted until disillusioned by the world of human life around him. Frequently the discovery of right and wrong and the fact that all in the world is not good, is a source of keen distress and worry. It is difficult to understand *why* there should be dishonesty, hypocrisy and deceit. A child will himself deceive with no qualms, but before he knows that it is wrong. He is self-centered and therefore he fails to draw moral consequences from his own acts before he apprehends like consequences from the behavior of others toward him. In the child selfishness lives with idealism.

Lack of Differentiation Between Imagination and Reality. Ninth, *the world of reality and the world of imagination are completely undifferentiated at first* and not fully distinct until the age of about eight or nine years. This fact explains the seriousness with which the child accepts tales of exploitation and adventure; it explains his inability to discriminate between the sensible and the ridiculous, the true and the false; it accounts for his original lack of a sense of humor; for

his exaggerations; and for the abandon with which he is absorbed in imaginary playmates, conversations, and occupations. If there is unhappiness in his relations with his parents, he may construct an imaginary father and mother, who have the qualities which his social needs require. These are 'foster-child phantasies' which, in abnormal cases, lead to a complete denial of the child's real parents. The undifferentiated condition of his world of imagination and reality may persist in the form of pathological lying, punishment for which usually increases rather than decreases the difficulty.

The Culture of Child Life. Tenth, it follows from the preceding characteristics of child life that *he possesses a culture fitting the stage of his mental development.* It is the culture of primitive man. The tools and implements in which he is interested are the simple implements of the savage. These he can understand. The toys he likes best are the simpler ones which he can apprehend as wholes. The imaginative world of humanized fairies, spirits, ghosts, giants, and dwarfs, both good and evil, is real and fascinating. The events in nature that attract him are much the same as for primitive man. He is a nature worshipper, fond of wild life and pets. Folklore, jingles, simple reiteration of sounds, simple rhythms and melodies, the bizarre and fantastic, are the themes of literature, art and music which he can understand and which, therefore, appeal to him. They symbolize the world he lives in, and are important factors in stimulating mental growth.

Imagination *versus* Reality: Value of Imagination. From time to time an educational theory rejects fairy tales and legends, like the Christmas story, on the ground that, later, when the truth is known, the child undergoes an emotional shock. Nothing could be more absurd. Premature sophistication takes from the child's life the natural and essential qualities of childhood. And as for suffering the pain of disillusionment later on, life is full of disillusionment and the personality that has known no disillusionment is ill prepared for the world of reality. To have believed in Santa Claus is to have learned the spirit of generosity and unselfishness *at the imaginative level where its value can be understood best.* It is the natural history of any important value in human life to have first been grasped

in a fairy tale, or epic, in the form of art rather than in the form of reality. The race itself has progressed in this way. It is the history of every great thought, every important precept, every far-reaching scientific discovery, to have been born in imagination. It is no more damaging to have learned that there is no Santa Claus, than it is for the scientist to have discovered that his theory of an important natural process is wrong, and must be changed. Changing from the supposed human Santa Claus to a symbol for the spirit of giving, happiness and thanksgiving, is no hardship when the supposed Santa Claus possesses these virtues for the child.

Generation by generation, the naïveté of children disappears at a progressively earlier age as the proportion of sophisticated and critical parents increases. It is a question whether or not civilization is prepared for this feature of its evolution, for the blasé spirit of youth, highly developed before there is adequate insight into human problems and an appreciation of higher values, leads to a cultural listlessness, cynicism and lack of idealism which is an unhealthy condition in any social order. The half-educated masses with sufficient knowledge to repudiate phantasy but insufficient knowledge to understand the real truth of its symbolism must eventually realize that the good life depends, after all, upon an idealism. It is a law of nature. Hypercriticism comes with half-knowledge; it is a sign of immaturity of mind. It is characteristic of the mind that has freed itself from tradition without knowing the importance of tradition and without developing a substitute. It is for the best interests of civilization that the child's interests in legends, folklore, simple epic poetry, music and art be preserved, that he may safely pass through the stage of independent thinking to a later period when he will have acquired a larger, philosophical understanding of life.

Idealism of Children. Eleventh, while the child is an unqualified utilitarian and pragmatist when living in a world of reality, *he is equally an idealist in his world of imagination, and the goals that function in the real world obtain their value from this idealism.* The values of actual goals are subordinate to the values of his imaginative world, just as local movements are subordinate to mass action, and as cells and organs are subordi-

nate to physiological gradients. *The whole which conditions the activities of its parts in the mental life of the child has the quality or field property of imagination.*

This is why goals, in child-life, *are their own reward.* Until taught to expect them, he requires no bribes, ulterior motives or persuasion, in order to learn or to achieve. Truth and knowledge have value in their own right; the child learns for the sake of learning; achieves for the sheer pleasure of achievement; expects no rewards except interest on the part of others in what he is doing. He needs little or no praise; he wants only companionship and participation in his adventures, the feeling that others share the delight and the glory of reaching, with him, a goal for its own sake. This basic law of nature is continuously violated, in the management of the child, at the expense of subsequent insight into life. *The goal is its own reward because it satisfies the desire which led to it; it is its own reward, because it, alone, relieves the tension.*

Nature abhors insincerity, bribes, hypocrisy. This is proved by the conflict and devastation wrought by these conditions in the world of human nature. They are the products of ignorance and lack of social insight; they are proof that children are brought up *poorly prepared for the problems which confront them.* They are proof that adults stupidly make the life of the child artificial by introducing into *his* world so many conditions that are naturally foreign to it, that it loses its sincerity and potential morality. Bribes, rewards, insincerity and hypocrisy are not known in the animal kingdom! They are not known in the child. These are products of civilization and are signs that man has invented as many problems as he has solved in the course of social evolution. It is an eternal problem to rid social life of these unsolved problems of living together, all the way from the home to races and nations.

Happiness of Childhood. Twelfth, the basic disposition of the child is *to be happy rather than to be unhappy.* Unhappiness is forced upon him. In spite of frequent hardships and deprivations, children reveal in their play activities and manner of living a spontaneity that demonstrates the basic nature of happiness. At first he accepts discipline as rough play.

No child can be properly disciplined, nor can obedience and

co-operation be expected in the end, unless the discipline is given in the spirit of sympathy and tenderness. The punishment is seldom understood in the way intended by the discipliner, for his world is a different one. The child is forced to adjust himself to demands which to him are artificial. This can be forgiven, if, in return, sympathy and friendship are obtained. But, if not, the consequence is resentment, fear, hostility and lack of co-operation. The acceptance of punishment as rough play is found alike in animals and children, and is *the primitive antecedent of the sportsmanship that is found at a higher level of response.* The ability, therefore, to accept defeat without resentment and to lose graciously is based upon a preservation of this primitive attitude of happiness at all times. If this disposition is repressed early in life, the individual, whether dog, child, or adult human, suffers for it the remainder of its years.

Creativeness in Child-Life. Thirteenth, *because goals are their own rewards, the child lives the life of a scientist, artist, inventor, adventurer, and romancer.* His is a life of serious research and exploration. He learns by creative thinking; each task, mastered, is a discovery. His play is work, and his work is play. He is basically serious and derives happiness from being serious. Reading his first story furnishes a thrill of achievement as great as comes to the scientist who discovers a new comet; his first letters are as important as the writer's first novel. His first addition is as stupendous as the discovery of relativity. One day Lois came dashing home from school, burst into the house and screeched, "Mother, Mother, I have something to tell you; two and two are four." She did not need to inform her mother of its importance. She told it in the intensity and quality of her voice and in the enthusiasm of her manner.

The Child a Social Being. Fourteenth, the child is essentially *a social being.* He must have companionship both from those of his own age and from his elders. But his world is primitive. By implication, he expects companionship from adults *at his level;* yet he expects to learn from them. He expects the same enthusiasm, abandon and interest to be shown in his games, that he shows in them himself. Without these

values play is no fun; the game is spoiled. And, in the long run, without these values, his life is spoiled. Deprived of this type of companionship, understanding and confidence in early life, corresponding relationships between older youth and their parents cannot be expected.

On the other hand, adult companionship, alone, is fatal. First, it matures the child too rapidly; it brings on premature nervousness and a maladjustment that shows itself in chronic grouchiness. Second, it forces the child to live a life of sham; to accept, for social reasons, values that are relatively meaningless to him. It produces an artificial human being, and the artificiality persists. This is the reason why the 'only child' presents a serious problem. In such cases, parents must expect that their child will, of necessity, be forever bringing young companions to the house, or he will remain away from home a considerable proportion of the time in company with those of his own age.

The Insight of the Child. Fifteenth, from the fact alone that the child's mental life is unanalytical and undifferentiated, as compared with an adult's, *he is capable of sensing and responding to situations which an adult will almost always overlook.* His insight into the intangible, especially into human nature, is in fact superior to that of the average adult. This is because the adult, in responding to his fellows, fails to perceive the tree for the leaves. Analysis is achieved only at the expense of the wholes that are analyzed.

Accordingly, children are expert judges of character where character affects them. They are clever judges of human relationships. They will understand attitudes, family relations, the texture and outline of an individual's total personality, long before they have names for what they are observing, and long before they know to what they are responding. But their precision is manifested in their remarks and in their attitudes. They can detect affectation and artificiality; sense undercurrents of suspicion, hostility, deceit and disloyalty, whether between brother and sister, father and mother, *or teacher and pupil.*

There is nothing remarkable about this, after all. *Children mature in dynamic relation to a melody of personality-relations*

in the social world about them. They sense the melody before they perceive discrete gestures made between the personalities concerned. This explains the astonishing character of the child's inventiveness, such as the following incidents illustrate. Lois, at five years of age, was being sent to bed early, one night, because her father and mother were going out. As they were dressing, she stood in the doorway of the sleeping porch and suddenly burst forth, "You are always going out and making me stay at home, alone! Some day, when I get big, I am going to get married, and I am going out every night, and you will have to stay at home, alone. Then you will know how it feels." What answer is there for a penetrating logic like this? Note that her remark contained the extremes of naïveté and sophistication. To be able to go out every night meant to be married! The sophistication is apparent in the thought that if her parents were required to stay at home while she went out, *they* would feel the lonesomeness which *she was now subjected to.*

At another time Lois, at the age of six, was being admonished for the persistence with which she played with one little boy in the neighborhood. Her mother explained, "You want more than one friend. There is Mabel whom you have not played with for a long time; there is Johanna, and there is David." "Well," Lois replied, "I like boys a lot better, they know more than girls." "Then why don't you play with David once in a while?" asked her mother. "Well," Lois replied again, "I don't see anyone playing around here with you except Daddy."

Notice that all through this discussion of the child's personality the familiar laws of dynamics are implied. It is one of the outstanding achievements of the twentieth century that science in general should be discovering a set of laws that are applicable at once to the physical, biological, psychological and moral aspects of human behavior. These laws show optimistic promise of placing principles of discipline on a scientific basis, not only in small situations, where a few individuals are involved, but in larger situations, where political, economic and international relations must be brought under control.

The Child's Personality Summarized Under Organismic Laws. 1. *The Law of Field Properties.* Before the child's personality can be understood it must be observed as a whole in the complex life situation in which it is found. Personality possesses a field property or form of its own which is called in everyday language by the name of individuality. Individuality, then, is the property of the whole over and above its parts. The parts are traits of character, taken separately.

2. *The Law of Derived Properties.* Each trait of character derives its property from the total personality. A trait in one child means quite a different thing from the same trait in another child, for the total personalities are different. Therefore, the differentiated traits must be studied in their relation to the wholes of which they are parts.

3. *The Law of Determined Action.* When seen as a segregated whole, the total personality determines the nature and value of each individual trait. In turn the total personality must be seen in terms of the social whole of which it is a part, for it is that social whole—the human nature-pattern that surrounds the individual—that determines the nature of the individual personality. The individual personality is an adjustment to the types of personality around it and to the demands which these personalities make upon it.

4. *The Law of Individuation.* Particular traits of character emerge from a primary, undifferentiated, and nondescript personality. Each trait is related to all the others as it emerges. The several traits emerge together. In turn, the personality as a whole individuates from a field of human nature that we call society.

5. *The Law of Field Genesis.* The child's personality evolves as a whole. It is an expanding, differentiating total pattern. The pattern is not a bundle of so many separate traits; it is not a whole constructed out of parts, it is all 'one piece' from beginning to end.

6. *The Law of Least Action.* The child's personality is constantly striving toward the goal of balance or equilibrium. It demands harmony within itself and between itself and its social environment. Each trait that develops is a process of resolving a state of disequilibration; each act carried out is a

process of resolving tensions induced by social environment. One trait develops in the course of balancing another.

7. *The Law of Maximum Work.* A trait of character never changes without a change in the total personality. Correcting an undesirable trait is a process of readjusting the personality as a whole; all other traits undergo a change at the same time. Similarly, when a given trait is induced, or when it is improved, the total personality is changed. The effect of strengthening or diminishing a particular trait can be observed in changes that occur in all other traits.

8. *The Law of Configuration.* The effect that corrective measures will have upon a given trait depends upon the extent to which all other influences are affecting the personality. In other words, the personality never responds to an isolated influence. It responds to that influence in its relation to all the others that are exerting an effect at the same time. There is no one to one correspondence between a particular outside influence on the personality and the change going on within the personality. Each change that the personality undergoes can be understood only in the light of a total situation.

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CHAPTER XIII

ANALYSIS OF THE LEARNING PROCESS: MATURATION, GOAL, INSIGHT

Methods of Analysis

Introduction. Now that the laws of the nervous system have been ascertained as far as the facts will permit, and the evolution of the learning processes has been traced through the animal scale and the growth of the child, the next problem becomes an intensive analysis of learning as found under experimental conditions in the adult.

Throughout, certain laws of behavior have been in evidence. These laws, instead of being mechanical, are organismic laws, formulated about the basic idea that the human being, as a unified system of energy, exhibits patterns of behavior whose function it is to preserve this unity while the system grows and becomes ever more complex. These are laws of personality, intelligence, will and maturation, not laws of drill, practice and the forming of associations.

Structural Analysis. Before analyzing the learning process further, it will be helpful to consider the problem of analysis, itself. There are in general two kinds of analysis, each of which has its value as well as its limitations. The first of these methods is *structural analysis,* which is the reduction of a whole to its parts. This method has two important limitations: first, the parts, analyzed out of wholes, are *new* events, different from anything that occurs in the complex process before the analysis is made; thus, description of the parts gives artificial data concerning the original process. Second, the complex process is more than the sum of its parts and cannot be explained by combining the parts after they have been obtained by analysis. Rather, the complex process is a primary unit, determining the properties of the parts. Structural analysis

can only give, therefore, a *description* of the learning process, nothing which will in any way account for what originally took place.

Consider some examples of structural analysis. If we should use this method on the chemical compound, water, we would end with hydrogen and oxygen. But both of these are gases, whereas water with which we began is a liquid. The property of liquidness has disappeared, and we have new structures, with different properties from those possessed by the original substance. If the hands, legs, arms, internal organs, head and all the rest of the parts of a man were laid out on a table, search as one may, the man is not there. *He* is something which is more than so many parts and which disappeared when the whole was broken down.

Structural analysis may be illustrated, also, from learning to read. We may take reading, in the child, and find in it eye-movements; we can find also that the child perceives letters, words, phrases and sentences. The error of structural analysis, however, is made when these descriptions of letter-perceiving, eye-movements, word-perceiving, sentence-perceiving, recognition of printing and script, are taken and put together again as explanations of reading. These aspects are abstractions which will not account for the learning process. They are processes that emerge in learning to read, but are derived from a larger field of activity than reading itself, a desire for knowledge and self-expression, and are explained by that larger field. The whole explains the part. The perception of the word conditions the property of the letter; and the sentence the meaning of the word; in each case the gross perception comes first and the details emerge in an orderly fashion from the larger whole. The parts are to be explained, not to be employed in explaining.

Structural analysis has, however, two important functions. First, in case of a complex event it is often impossible to study the whole at one time, because the conditions on which it depends are too numerous, and complete experimental control is impossible. The problem must be simplified. Structural analysis arrives at this end by segregating parts for special study. In biology, for example, it is impossible adequately to study the

whole body at once; therefore, some part of it is isolated, either by dissection or by experimental methods that ignore more than a part. The study of anatomy is structural analysis *par excellence.* Second, a description obtained by the method of structural analysis often leads to clues about the whole from which the part was segregated. Thus, by structural analysis of the stomach, one learns that it has an opening through which it receives food, another from which it discharges food and that its walls contain muscles and glands of secretion. These are the necessary preliminary facts for a study of digestion and for an understanding of the rôle played by the stomach in the total life process of the individual.

Functional Analysis. The second procedure is called *functional analysis,* and is the method of varying the conditions under which a given event takes place, for the purpose of ascertaining the conditions necessary for its existence. Facts thus obtained lead to prediction and control. Functional analysis *need not* reduce a whole to its parts. It tells us what happens to the whole under sets of conditions that modify but preserve it. We found that structural analysis 'divided' water into hydrogen and oxygen. Functional analysis studies the properties of water itself under different conditions, such as heat and cold, or with various substances in solution. The water has different properties under each of these conditions, but is not destroyed.

Our intensive investigation of the learning process will be carried out largely by methods of functional analysis. We shall be concerned with the conditions under which learning takes place, in view of ascertaining which of these conditions are *most effective.* Throughout it must be remembered that the process of learning is a unit in space and in time. It cannot therefore be treated as a sum of so many elements or skills, derived by structural analysis, but as a total, unified process, operating under a given *set* of conditions. Such factors as maturation or growth, the goal, motivation, recitation, 'repetition,' and kind of material to be learned, will be dealt with, in turn, as the conditions of learning.

The Problem of Maturation

The Rôle of Maturation in Learning. It has been suspected, all along, that maturation is a basic condition of the learning process, even in human adults, for it was basic to the development of motility in the embryo, to the evolution of the learning process in the animal scale, to the infant's acquisition of motor co-ordination, and to the development of intelligence in the child. The effect of maturation, as seen in the behavior of the organism, was a definite cycle of the behavior-pattern, commencing with mass action and progressing by differentiation. No experiments have been reviewed, however, that demonstrate, by means of functional analysis, that maturation is, definitely, a condition of a specific learning process, placed under control. These experiments will take us back, momentarily, to animal behavior. The results will determine whether maturation is the basic factor by depriving animals of a chance to repeat a given performance. If progress is made under these conditions then we shall know that maturation is fundamental.

Maturation Demonstrated: Bird's Experiment. A study by Bird,[1] on the chick, demonstrates the importance of the maturation process. It had previously been held that repetition of the movements was the sole condition of perfection in pecking. Bird tested this theory by hatching large numbers of chicks in darkness and confining them there for varying periods of time, until they were taken out for purposes of experimentation. Four groups of animals were used; the first was removed from the dark immediately after hatching; the second group was removed at the end of 24 hours; the third at the end of 36 hours, and the fourth after 48 hours. The chicks had not practiced pecking to the time of their removal from the incubator, for it has been found that they will not peck in the dark, even when hungry. The results of this study indicated that the older the chicks when removed from the incubator, the more accurate their pecking movements. This meant that a curve resembling

[1] Bird, Charles, "The Effect of Maturation upon the Pecking Instinct of Chicks." *Ped. Sem.*, 1926, Vol. 33, 212-243. Also *Ped. Sem.*, 1925, Vol. 32, 69-91, and from unpublished manuscript.

a learning curve was obtained, which could not have been the result of practice, but the result of maturation. (See Fig. 28.)

The experimenter allowed each chick 25 trials and then returned them to the dark. After their second period of practice they were not returned to the dark, but permitted to feed. The curve shows the initial performances of the four groups. Group 1, tested on the day of hatching, made less than one complete pecking and swallowing reaction in the 25 trials. The one-day-old chicks made an average of 1.8 swallowing reactions; the two-day-old group made 2.64, and the three-day-old group scored 3.58. The second performance of group 1 was 2.9, a record almost equaled by group 2, which started, on the second day, with no practice. The second performance of group 2 was 5.6, while the first performance of group 3, the same age as group 2, was 3.58 with no practice. The second performance of group 3 was 5.10, which was almost equaled by the first performance of group 4 with 4.63. It is evident that there was only a small difference between the practiced chicks and those which matured in the dark without practice. The small difference could well have been conditioned by the greater vitality of the chicks that had been given an opportunity to exercise and feed in sunlight and better air.

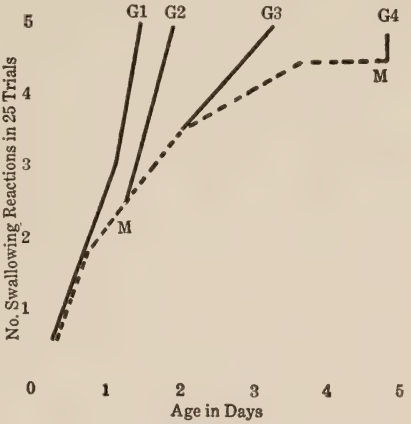

FIG. 28. CURVE OF MATURATION IN YOUNG CHICKS (Bird).

The curve of maturation (M) was obtained by connecting the beginning points of the learning curves of four groups of chicks, G1 to G4, whose complete curves are not shown. The rise in the curve indicates improvement in initial performance conditioned by age of the groups. (From unpublished manuscript.)

This study by Bird has a far-reaching significance with reference to the learning process. Various investigators had already found that practice, or repetition of response, is not as important as the spacing of the repetitions in such a way that

the learner is given a chance to mature with respect to the problem. It is just this maturation process that Bird studied. The learner, whether it be a chick or a human being, grows to a more difficult and complicated task between 'repetitions.' Each time he attacks this complicated problem after maturation has taken place, he is able to perceive a more complex stimulus-pattern. *The goal is perceived, along with the method of reaching it, in a greater detail of relationships.*

Carmichael's Experiment. Carmichael studied maturation in the embryos of the frog and salamander after they had been removed from the influence of external stimulation.[2] Before the embryos gave any indication of activity they were placed in a solution of a drug, called chloretone, which does not prevent maturation, but inhibits activity. A control group was placed in ordinary tap water. When the control group were mature enough to swim well, the drugged organisms were placed in fresh water. After a short period in which the anaesthetic was disappearing, *the experimental group moved about as freely as the control group.* In order to determine whether this delay required by the experimental group was a time necessary for the drug effects to be eliminated, or a period of very rapid learning, Carmichael anaesthetized another group of embryos. He performed the experiment as before, except that after they were swimming freely, he returned them to the chloretone solution for twenty-four hours. When placed in the fresh water at the end of this period, the length of initial inactivity was as great as before. It was therefore concluded that the delay did not involve learning. Another check was introduced by letting one group of embryos develop in a noisy room, another in a quiet corner of the laboratory, and still another in a sound- and light-proof room. When the first two groups had developed free swimming movements, Carmichael quietly entered the sound-proof room and flashed a light on the vessel, whereupon the animals darted around with the same speed of movement as those outside that had been subjected to constant stimulation. *This study indicates in gen-*

[2] Carmichael, L., "Development of Behavior in Vertebrates Experimentally Removed from the Influence of External Stimulation." *Psy. Rev.,* Vol. 33, 1926, 51-58. Also *Psy. Rev.,* 1927, Vol. 34, 34-47, and 1928, Vol. 35, 253-260.

eral that the swimming activity was a result of maturation, not of exercise, and is in accord with Coghill's results, discussed in Chapter III.

Review of the Evidence for Maturation. The evidence for maturation as the basic condition of learning seems complete enough. It came, first, from the study of the organism's original movements, where walking, swimming (Coghill; Carmichael) and pecking (Bird) progressed in the absence of practice. In this connection it has been found that new-born chicks, deprived of external stimulation for two weeks, lost their pecking reactions entirely, although they had been artificially fed. They would then starve in the presence of food if left to secure it for themselves (Padilla). Second, evidence came also from a study of the learning process in animals, when problems were solved the first time, or where a sudden spurt in learning occurred. Third, we shall find that the time intervals between repetitions in problem-solving are of great importance, while mere repetition has *no* explanatory value. All this indicates that maturation takes place not only before the organism reaches its limit in size and weight, but afterwards as well. It is this process that makes possible the perceiving of a stimulus-pattern in increasing detail and in wider and more comprehensive relationships.

Illustration of Maturation in Everyday Life. A good illustration of maturation in a specific learning situation in everyday life is the progress that a person makes in playing tennis. He must grow to a mastery of the game. This growth process commences with a relatively undifferentiated perception of the problem, and continues in an orderly fashion, through expansion and differentiation, until the ultimate goal is reached. Wertheimer has given a technical name to the process of reaching the goal such as the one in this situation, or in any behavior situation. The name is 'closure.' [3]

The person setting out to learn tennis first perceives *in a general way* that he is to hit the ball over the net; this perception is undifferentiated at the outset, however, involving no knowledge of the correct stroke or of the intensity with which to hit the ball. It is only when the person has matured suffi-

[3] Koffka, K., *Growth of the Mind.* New York: Harcourt, Brace, 1924.

ciently with respect to the detailed problems of tennis that he has learned the game. He must *discover* that a ball served in a certain way must be returned with a certain kind of stroke; that a ball in a certain place in the court must be hit with a certain force. His perception of the ball in relation to himself, and in relation to the court, must undergo a differentiation and at the same time, an expansion process, before mastery is achieved. Physiologically, *this has come about through a multiplication of synapses and a differentiation of the energy-field of the brain, not through use of synapses. Later on, when the problem of memory is discussed, we shall learn what happens to these synapses or to this differentiated field in the absence of 'practice.'*

The Goal in Learning

The Goal and the Learning Process. From previous discussions it is clear that all details of the learning process are *features of a single, unified response, a goal-activity, which is conditioned by a stimulus-pattern, part of which is environmental and part of which is intraorganic.* This fact enables us to define goal in a technical, psychological sense. Just as the center of the earth is a *locus* in a gravitational system, *a goal is a locus in the stimulus-situation to which the organism is responding.* This locus may be part of the objective situation as in case of food perceived; it may be imagined, as in case of food anticipated; it may be more general, like the completion of a task set up for an observer in the laboratory. Here it is still a locus in the stimulus-pattern, for it involves the manipulation of apparatus or accomplishing something with respect to an objective, experimental situation. In any case it can be brought under control and varied in order to ascertain its importance. Then it is controlled by subjecting the stimulus-pattern to control.

We must put this stimulus-pattern under control and proceed to a further functional analysis of the learning process. The first experiments to be reviewed demonstrate how learning depends upon a goal. This means that it never takes place without a *will to learn.* In turn, the will to learn depends upon an understanding of definite and explicit instructions, either self-imposed or given the learner to fulfill. The importance of

the will to learn was well illustrated by Ebbinghaus [4] years ago. He exposed to himself a list of nonsense syllables which he repeated many times with little intent to remember them. At the end of 50 repetitions he could recall scarcely a single syllable. However, when he tried rigorously to master the series he learned 12 in as many repetitions; he now had a goal; he had given himself definite instructions.

Peterson's Experiment. Peterson [5] performed an experiment with a class in psychology on the importance of the will in learning. He presented two groups of students with lists of words. One group listened to the words passively, with little intent to learn them, while the other group tried to learn the list for subsequent recall. At the end of the experiment he asked both groups for a recall, and again at the end of two days. The effect of the definite goal was to increase immediate recall 22 per cent, and delayed recall 50 per cent, over the performance of the other group. Thus the effect of a precise goal was very striking, especially in the case of the delayed recall.

In both of these experiments there was no learning when there was no goal. The goal was set up by the instructions given the learner, and once set up, reaching it was anticipated by the learner.

The goal must be present before learning activity *commences,* whether it is a rat running a maze or a human subject learning a list of words. But this is not all. In case both of the rat and the human being the goal and the method of reaching it *are perceived in relation to each other before the activity of running, or of learning the lists of words, takes place.* This perception was absent in the first part of Peterson's experiment, and because there was no goal, and no perception of a procedure, the first group could not later retrace their steps and pick up the goal, or, through an effort of will, recall the syllables in an adequate fashion.

Importance of Definite Goals: Book's Experiment. The importance of definiteness of the goal can be demonstrated by experiment, as Book has done in an investigation on Educa-

[4] Ebbinghaus, H., *Memory* (Tr. Ruger). New York: Teachers Coll., Col. Uni., 1913. (Original date, 1885.)

[5] Peterson, J., "The Effect of Attitude on Immediate and Delayed Reproduction. A Class Experiment." *J. Educ. Psy.,* 1916, Vol. 7, 523-532.

tional Psychology students at Indiana University.[6] Prior to this time, Educational Psychology had been an elective subject at Indiana, taken by students who were preparing to teach. In 1924 it became a required course for all students who were qualifying for a teacher's certificate. Noting a marked change for the worse in the interest with which the students pursued their work after this requirement went into effect, Book questioned 147 of them concerning their real purpose in taking the course, and what they expected to obtain from it. He found that 66 per cent of the students took it because 'they had to' or because 'it was required to get a teacher's certificate.' Previous to the ruling, which made the course a burden, the students had taken Educational Psychology because they liked the work and believed it could help them in their teaching. They had a definite goal toward which to work, a goal that was intimately related to their interest in life. They pursued the work for its own sake and for the sake of the understanding it was to give them. With the introduction of the requirement, however, the goal was now 'get through the course with the smallest amount of effort'; the requirement had made the course something which the student had to take. Mastery of the course was no longer a definite goal, but an indefinite and unpleasant task, to be avoided by fair means or foul. The definite goal meant efficient learning of the task, whereas the indefinite one meant a vast waste in time and effort.

There are other illustrations of the devastation wrought by indefinite goals. The inefficiency of learning in an immature child, forced by the school curriculum to learn tasks that, to him, have no immediate connection with life and future interests, is a striking consequence of indefinite goals. The same situation is also found in animal experimentation, where the problem is so complicated that the animal fails to perceive the goal imposed by the experimenter.[7] Then, instead of solving the problem, the animal sets up goals of its own, such as escape, to return to the home-box, or to explore. The animal may even ignore the experimental situation entirely. In like

[6] Book, W., "How to Develop an Interest in One's Tasks and Work." *J. Educ. Psy.*, 1927, Vol. 18, 1-10.

[7] Thorndike's experiments on cats well illustrated this point. *Animal Intelligence.* New York: Macmillan, 1911.

manner, the child who cannot understand the relation between a given school subject and life as he sees it, will substitute goals of his own, such as achieving some exploit in a daydream during the class period, or of just 'getting by' the course, or of tolerating a distasteful task in order to enroll in more desirable courses later on.

An Application to a School Situation. We have seen all along that the route to a goal, no matter how intricate the procedure of reaching it, is one route, for there is only one goal. Suppose that the desired goal of a given learning process is the mastery of an economics lesson. There should be but one route to the goal, with thought of nothing else. That one route, the shortest, should be the direct learning of the material for its own worth. But if the conditions are such that *another* goal is set up, grades, for example, learning will of necessity take place over a *different route,* involving means of *grade getting* as such, cramming for an exam, getting by in the course or cheating. The undesirable consequences of this state of affairs are numerous and far-reaching, especially when the desired goal, to begin with, is indefinite.

Summary of Facts About Goals: Different Types of Goals. There are many kinds of goals. A goal can be an object to reach in a certain place in space, such as a cookie in the cupboard or a chair in the cool shade of the terrace; it may be more abstract such as the goal to obtain an education or to earn a living, or to give one's children a business opportunity. It may be 'somewhere in a given region' such as a region of safety when one is threatened suddenly by an approaching automobile. When one is hunting grouse, or when one is fishing, the goal is 'somewhere' in the thicket or 'somewhere' in the pool. For the rat, before the maze is learned, the goal of food is 'somewhere' in the 'maze.' When the novice commences to practice on the piano the goal is a certain degree of proficiency in playing, or when he begins a foreign language his goal is a speaking or reading knowledge of the language. The approach to any one of these goals obeys the law of least action and the final achievement is a 'closure.'

The Changing Goal: Relation of Goal to Maturation. In human life a goal is never a static thing. It changes with

maturation, for goals are relative to the degree of differentiation both of the individual's nervous system and of his experience. The history of any goal is the history of any given pattern of behavior. It is first undifferentiated, general, indefinite. Recall the illustration of the tennis game. When a person is on the court for the first time, his goal is to land the ball 'anywhere on the other side of the net'; later, anywhere in the proper court, then in a certain place in the court, as for example, as near the back line as possible, in order to confuse the opponent. Finally, it is not only a goal involving placement of the ball but giving it speed and curve. The goal that a father may have for his son is, first, to send him to college. This is only a general goal. Subsequently, it may be the aim of having him major in a particular subject; then the goal of having him become a university professor.

The rat's goal of securing food in a maze passes through the same differentiation process. The goal may be typified at the outset by the expression, 'I am hungry; there must be food somewhere.' Then it becomes, 'The food-box is somewhere in this general direction,' and later, 'The goal is one turn to the left, down this alley such and such a distance, a turn to the right, then to the left twice, back just so far, to the right just so far, and there it is.' Definiteness of goal, therefore, is a matter of degree of insight into the total situation of which the goal is a part.

Dual Reference Points of Goals. Goals always have two reference points, one, an environmental object or situation; the other, a condition within the organism, namely, equilibrium of stress. A human being is so adjusted to his environment at all times (unless he is abnormal, and then it is only a matter of difference in degree) that the same movement which produces equilibrium within, brings him to the environmental goal. This is because the process of resolving the tension toward the goal *is* a movement of some sort. The condition of internal equilibrium depends upon reaching the environmental goal, and the existence of the environmental goal depends upon the internal tension. The hungry boy is under internal tension, produced by stomach contractions. This is a nervous tension which resolves itself into the muscles; the muscles contract in a

co-ordinated fashion and bring the boy to the cupboard. The tension is then resolved through movements of securing and eating the cookies. The resolution process takes the physiological form of nerve discharges and muscular contractions, and the psychological form of feeling the hunger, desiring the food, visualizing the cupboard and voluntarily making the movements of securing the cookies. It is the same story both times, told in different language. The resolution process does not move the boy; *it is the boy making the motions.* The situation that 'moved' the boy consisted of the conditions leading to the tension. These were the empty stomach and the general organization of the boy's nervous and muscular system which furnished at once the energy and the mental life capable of being affected in the way described.

These general points about different types of goals: the goal changing with maturation; the two sets of reference points, internal and external; and the fact that goals are always in some way consciously represented, are good points to keep in mind throughout the remainder of the Text. In a practical sense they mean that there is no goal without insight and no goal without will. They mean that to have goals the normal human being must be properly adjusted to his physical and social environment; that unless he has goals he cannot as much as move; that as he grows older his goals become more precise, but at the same time more complex and numerous; that in any new situation the goal is less definite than in a familiar situation; that in a learning situation, progress means a definitization of goals and the means of reaching them.

Goals in the Schoolroom. Important facts to remember about the goal in learning-situations are, first, that it is the low potential toward which activity will take place. It therefore gives direction and an end to the activity. Second, the goal must be perceived before *anything* will happen. Third, the desired goal should be the lowest potential in the field of action at the time, guaranteed by making the goal vital and interesting. Fourth, indefinite goals are difficult to perceive, and *always* result in the setting up of extraneous goals. Fifth, the goal derives its property of attractiveness from a meaning

given to it by the total life-situation in which the learning takes place, not from any force which it possesses by itself. This explains the importance of definite instructions and clear-cut explanations of values. Sixth, activity from the perceiving of the goal to the 'closure,' or reaching of the goal, will take place over the shortest route in time. *There is only one route to a given goal.*

Interrupted Tasks: Lewin. The importance of maturation and the goal in learning lead us to the problem of the resolution toward the goal. The perception of the problem, as we have seen, involves not only the setting up of a high potential or tension, but also the perception of the goal and the path over which to proceed toward it. If, however, the task to be learned is interrupted before the goal is reached, but after the learner has perceived the problem, the learner is left with an unresolved tension. Lewin [8] demonstrated this fact in an experiment on a group of children and adults. He gave them various tasks such as sketching, printing names and assembling puzzles. In certain cases he stopped the learners before their tasks were completed; others he permitted to complete the tasks. After a day's interval, he asked his subjects to recall what they could of their previous activity. The result was that adults remembered the uncompleted tasks 90 per cent better than the completed ones; the children remembered the uncompleted tasks almost exclusively. Evidently the learner had not been removed from the stimulus-pattern, and as a consequence was still under a tension. It was this tension, which, in the *interim,* the individual had been attempting to resolve toward a completion of the task, that conditioned the better recall. In the case of the completed task the tension had been resolved. The child that begs to stay up at night in order to finish a story is exhibiting this same momentum of the resolving process. *If* he is forced to retire, he will recall more details concerning the story in the morning than the child who finishes the story at night. No one likes to be interrupted in the middle of a task, as can be seen from an earlier discussion of the law of increasing energy.

[8] Lewin, K., "Untersuchungen zur Handlungs und Affektpsychologie III." Zeigarnik, B., "Das Behalten erledigter und unerledigter Handlungen." *Psy. Forsch.,* 1927, Vol. 9, 1-85.

Practical Facts About Unfinished Tasks. It is important to remember the inevitable tension left in an individual when tasks are unfinished, or goals are thwarted. He is unhappy until the task is finished. He is irritable, nervous, unable to concentrate on other things, or at least he is uninterested in other things until the tension is resolved. This is particularly true when a person is near the goal or when he is under intense motivation. It explains the difficulty teachers experience in interesting their pupils when the latter are preoccupied with something else. The interference leaves them with 'unfinished tasks.' Under these conditions the goal which the teacher desires for the pupil must be made as attractive as the opposing goal, or she will be unable to organize his mental processes toward the prescribed task. Threats, punishment, and bribes will be of little avail. The task must interest the child because of its intrinsic value for him.

Insight in the Learning Process

Expansion of the Total Pattern in Learning. Practically nothing has been said thus far regarding the *expanding character* of the learning process *in the adult.* It was pointed out in connection with the behavior of animals that the simplest responses were those of moving over a given route to the goal. This was followed in higher animals by *choosing* a certain path, labelled, along with other paths, by a brightness, or color, or some other cue. Still higher animals were able to *perform complicated motor responses on the way to the goal,* such as turning a latch; and finally, the more advanced types were able to *use movable tools as means to an end.* In the study of the infant these same types of responses were observed in the early stages of development, but were soon supplemented by the use of language, and more complicated tools, than in the case of animals. Throughout all these stages the process of solving a given problem started in each case with an undifferentiated perception as compared with the later, differentiated process at the time the task was perfected. This undifferentiated perceptual field and the resulting undifferentiated movements, however, *were organized at the very beginning.* As maturation took

place the process became more differentiated; *it expanded as an organized pattern* both of perception and of movement. The parts that emerged, later, were not additions to the early process, but were differentiations *out of* the already organized pattern. Thus, in motor learning, the first movements were awkward and gross; they had not yet differentiated to the point of being precise, but nevertheless, they were not random; they were made with respect to a goal correspondingly differentiated. Later, in the process, the finer muscular co-ordinations emerged, organized and ready to function when they emerged. This emerged response, which is the final learned response, is described from the learner's standpoint as the acquisition of insight. The problem of expansion and differentiation of the learning process, therefore, becomes a problem in the development of insight, and one to be investigated by functional analysis.

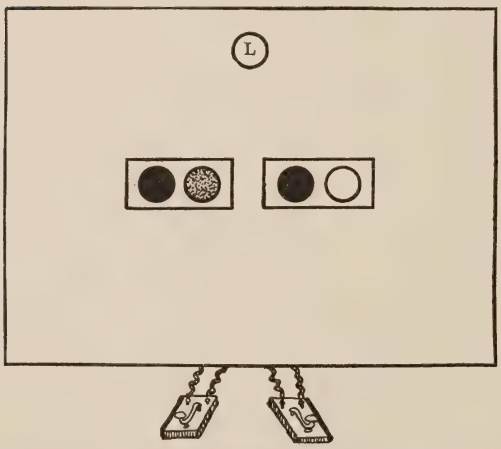

FIG. 29. FRONT VIEW OF PATTON'S APPARATUS FOR INVESTIGATION OF INSIGHT.

Shading represents the relative brightness of the lights. L is the pilot light which flashed when the observer responded correctly by pressing the appropriate key. For further explanation see text.

The Development of Insight: Patton's Experiment. The development of insight in the human subject has been studied by Patton.[9] He presented his subjects with two pairs of illuminated discs. Each individual disc could be varied in brightness value. The subject sat before a table some distance in front of a black screen in which the four lighted discs were located. (Fig. 29.) On the table in front of the observer were two push-

[9] Patton, E. K., *An Experimental Study of the Emergence of Insightful Behavior.* 1930, University of Kansas. Dissertation.

button keys, one corresponding to the right pair of discs and the other to the left. The apparatus was constructed in such a way that if the right pair of discs was correct a small light would flash on when the right key was pressed by the observer, but if the left key was pushed nothing would happen. If the left was correct the opposite was true. Each light-source could be varied through a range of seven values of equal steps, called high-bright, bright, low-bright, medium, high-dim, dim, and low-dim. Thus there were numerous possible combinations of lights. Patton selected a series of combinations in which the absolute as well as the relative position and relative values of each disc were varied after each response of the subject. He arbitrarily selected four possible solutions to the problem. These were, first, selecting the pair that, between its two members, showed the greater difference in brightness; second, the opposite of this, the pair of lesser difference; third, selecting the pair whose members, summed together, possessed the greater brightness; and fourth, the opposite of three, the pair with lesser summation of brightness. The number of correct responses on the right or left side was arranged in chance order and the series could be reversed or the order entirely changed to guard against sheer memorization.

Patton brought his subjects into the experimental room and seated them before the table, *without giving them instructions of any kind.* He arbitrarily decided what solution was to be correct. He then went behind the screen and started his series of light combinations. After a short period, if the observer had not reacted, he demonstrated how the push-buttons worked, but without verbal comment. The observer would then react at first on the 'hunch' that it was a right-left problem, then with some other theory. Finally, after long periods of time in some cases, most of the observers solved the problem. Then if the first problem had been that of greater difference between the members of the pair, the experimenter now suddenly (without the subject's knowledge) changed the problem to that of lesser summation, or to any one of the other three.

The Cycle of Developing Insight. From introspective reports both of naïve and trained observers, Patton found *that the subjects always worked on the basis of some theory or prin-*

ciple; their behavior was never without a goal. At first the theory was very simple and undifferentiated in character. It was a theory of a mere position-plan such as, "The correct choice is now on the right, now on the left." This theory sometimes differentiated to the more elaborate form of, "Every third correct choice is on the right." But a mere position theory did not work. The second step in the development of insight was *the recognition of some relation between the brightness values and position taken together, and the correct response.* For example, "The correct choice is on the right when the brightest disc appears as the outside member of a pair." But this plan was too simple. The discovery must ultimately be made that *greater difference* is the cue, or greater summation, or lesser difference, or lesser summation, as the case might be. This discovery always evolved in the course of differentiating and expanding the idea that brightness values and position were involved in the problem. The final correct response was not built up gradually, but emerged suddenly, organized as a total thought-pattern, a complete system of ideas.

It is important to note that *correctness of response could not come about by degrees, for the experimental method prohibited it. A plan was either totally right or totally wrong.* Moreover, there was no chance to learn *by* experience. The fact that the subject learned the correct response, then, means that it must have been discovered. The subjects reported that the correct plan dawned on them all at once, even before they were able to describe exactly what the theory was that they were following.

Peterson's Demonstration of Insight. Other evidence for the development of insight in the expansion and differentiation of a learning-pattern comes from an experiment performed by Peterson.[10] He told a group of 20 subjects that he had drawn a maze which he would show them later, each alley of which was marked by a letter. (Fig. 30.) The subject was to choose one letter out of two that were presented verbally, say N and V. If the answer was correct (V) the experimenter went on to the next pair of letters (C, H). Thus, when the

[10] Peterson, J., "Learning When Recency and Frequency Factors Are Negative." *J. Exp. Psy.*, 1922, Vol. 5, 270-300.

observer made a correct choice he had covered one section of the maze, but when he made an error, the experimenter went back to the beginning of the maze, to N, V, although the observer was not told what had happened. The observer was merely informed when he reached the goal, and mastery of the problem was considered complete when the goal had been reached without error three times in succession.

While this study was designed to test the rôle of frequency and recency in learning, pertinent data were secured regarding the nature of insight.[11] The observer usually began by making

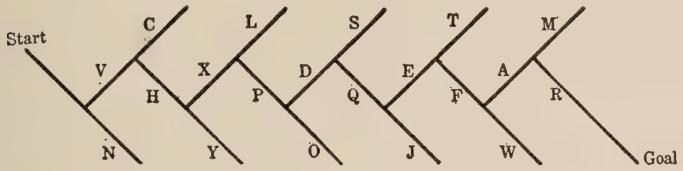

FIG. 30. PETERSON'S MENTAL MAZE (modified).

Choices V, H, X, P, D, and so on, are correct. N, C, Y, L, are blind alleys, or wrong choices. By permission.

a large number of errors in the first two or three sections of the maze, either by choosing the first letter presented each time, or by working on a complicated plan, such as alternation of choice on first and second letter, or choosing every third one first. All these, of course, netted the observer nothing. The next step was the memorization of the first three or four correct choices and perhaps an error, which meant that he must begin over again. The result confused him. As yet there was no perception of the fact that when an error was made the maze must be started over again; the observer thought that he was being presented a continuous series. The first real progress came suddenly, usually with an exclamation like, "Why, you start over every time." From this point on, the earlier part of the maze, already memorized, was passed over very rapidly each time after an error threw the learner back. By now he had discovered which letter, if chosen incorrectly, sent him back to the beginning of the maze, *and did not repeat the error;* while if he

[11] Some of the data on insight in this section are taken from observations made by the authors on beginning psychology students, in a repetition of Peterson's experiment.

found the experimenter giving him a new combination, he knew that his previous choice was correct, and *remembered it because of its relation to his progress.*

The observers were called upon to give reports at the end of the experiment and were asked to draw the maze which they had been traversing. All of them had imagined a maze that they could draw, indicating that for them the entire maze possessed a certain plan before the problem was learned. In fact this plan emerged in a vague way when they perceived that they were starting over again after each error. The last stages in the learning consisted in an expansion and differentiation of the maze plan in their imagination.

Practical Consequences of Insight: A Classroom Situation. The data of this section have indicated the importance of insight in human learning, and have demonstrated the expanding, emerging character of that insight. At the same time, they place repetition under control and prove that it is valueless. To develop insight was the only way in which the learner could progress. In the classroom the development of insight takes place in the same way as it does in experiment. Suppose a student is given the mathematical problem of adding ½ and ⅓. He may have the idea, first, that he should add the denominators, and, as the numerators are both 1, he should leave the numerator 1. But this gives him the answer of ⅕ and he reasons that half of a pie and a third of a pie must equal more than a fifth of a pie. He then tries the plan of adding both the numerators and the denominators, but this gives the answer of ⅖, which still looks smaller to him than something that is more than ½. He thinks, "Since ⅓ is almost as large as ½, the answer must be almost equal to 1." Finally, with a flash of insight, he perceives that the two fractions must be reduced to common terms. What explains this discovery? In the course of being stimulated over a period of time, maturation takes place. This means that he is able to apprehend larger and more abstract mathematical situations, as wholes. His thinking expands to the point where he can *apprehend the larger mathematical whole of which ½ and ⅓ are parts.* He perceives this whole in terms of a number divisible both by 2

and 3, namely, 6. This is the process of differentiating the larger whole. He then translates ½ into ⅜ and ⅓ into ⅖. Then, by adding, he obtains the correct answer, ⅚, which is almost the 1 which he had previously thought it should be. The flash of insight came when the student perceived that the theory of 'reduction to common terms' in a larger mathematical whole applied to this particular problem. It is only when the plan of the problem and its relationships to a general theory are perceived that one can complete such a task as this. Furthermore, this is not the only problem that can now be solved, for a principle has been discovered. To understand a principle is to understand a whole whose parts are all comprehensible in terms of the whole. In this case the larger whole is a mathematical system of which fractions are a part. Having added ½ and ⅓ the student can at once add ¼ and ⅕, or 5/12 and 7/14.

Similarly, spelling can be learned correctly only when the student can see the word, first, as a unit, and then perceive the letters, each in relation to its neighbors and to the whole word. When the learner has matured to the extent that insight of this kind is present, then he can spell correctly. The trouble is that many spellers never take the time to develop this insight.

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CHAPTER XIV

ANALYSIS OF THE LEARNING PROCESS: CO-ORDINATION AND MOTIVATION

The Problem of Initial Delay

The Initial Delay: Snoddy's Experiment. Continuing our analysis of the learning process in adults, the next problem becomes: What are the precise conditions under which motor co-ordinations differentiate from mass action? We know that they do. Are there any additional facts which will give us a clearer picture of the process? Snoddy [1] performed an experiment on human subjects which gives us certain details of the picture. He asked his subjects to trace a star-pattern in mirror vision. The learning process started as an undifferentiated motor, as well as perceptual, response. This is shown by the fact that the learner made a great many short and jerky, 'uncoordinated' movements at first, then gradually lengthened the straight line down the groove that could be drawn with one movement. (See Fig. 32.)

Snoddy was able to measure the speed of movement along the pattern by means of a camera and an interrupted electric light, fastened to the stylus with which the subjects traced the star. In Fig. 31 the black dots represent single flashes of light and the distance between them the speed of arm movement. It will be noted that *immediately before the subject turned a corner he decreased his speed; he hesitated before he made a new movement.* Snoddy called this a *period of initial delay.* It is a period when the subject was constructing a perceptual configuration of the path to be traversed. He was allowing time for the perception to become differentiated sufficiently to permit accurate guiding of the hand.

[1] Snoddy, G. S., "An Experimental Analysis of a Case of Trial and Error Learning in the Human Subject." *Psy. Mon.,* 1920, Vol. 20, No. 124.

This is how the perceptual configuration is formed: The subject is approaching the corner of the star but he has not yet perceived the distance to the corner, and the size of the angle to be traced. He has merely seen that the corner is there in its general relation to the entire pattern. But the corner is then perceived in greater nicety of detail. At the same time, the muscles of the hand and arm are 'set' for the correct movement, although motion of the hand and arm does not entirely stop.

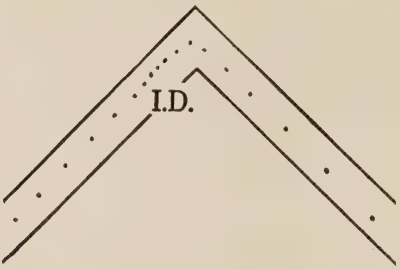

Fig. 31. Illustration of Initial Delay (I.D.) (Snoddy). Explanation in Text.

In the final stages of the learning process, where speed and accuracy have been attained, Snoddy found that the period of initial delay came at the starting point on the star. There the learner poised the stylus, perceived the star as a unit, and proceeded around it with a single rapid movement.

Relation of Initial Delay to Motor Skill. All muscular co-ordinations arise in this way; they are formed as the learner perceives the goal in its detail of spatial relationships to himself. The co-ordinations are the end-products of perceptual configurations. Once the goal and the method of reaching it are perceived the movements take care of themselves. In executing delicate feats of skill it is best, for this reason, not to think about the movements, as such, or try to change them after the response has commenced. If the learner then tries to change he exhibits the awkwardness of 'over effort.'

Types of Initial Delay. Initial delays occur in other types of muscular co-ordination. The golf player raises his club and hesitates before the downward swing, else he makes a poor stroke. During this hesitation he is constructing the action-pattern for the final swing. If he changes his swing on the way to the ball he is certain to chop the stroke. The muscular action-pattern is already formed in its entirety and to change any part of it is to unbalance the entire stroke.

This type of a response occurs in other fields as well. Perkins' goldfish frequently swam around the entire outer compartment, actually looking over the situation before making a choice; this obviously was the time necessary for the formation of the perceptual configuration, which was to determine the movements made in reaching the goal. In an experiment by Lewis [2] on chicks, a similar fact was observed. After the chicks had been presented a problem similar to that given the goldfish, an extra compartment, facing away from the animal, was added. When it had already made its choice from the starting place, and was on its way to the light, it discovered the extra compartment and *hesitated* while its perceptual configuration was undergoing the necessary change. *When either the fish or the chick failed to hesitate, before it chose, it more often made errors.* Invariably, in the final stage of the learning process the animal made its choice from the position where it was originally placed in the apparatus. It was able to construct its perceptual configuration, in advance of a long series of movements, as did Snoddy's subjects at the beginning of the star after skill had been acquired. In Bingham's monkeys, this perception of a total pattern at the beginning of a series of movements was very obvious. The monkey would hesitate and visually inspect the problem, then proceed to the necessary manipulations, *oftentimes with its back to the goal.* Obviously the animal must have constructed the motor pattern during the initial delay period, or the movements would not have been organized with respect to the goal. And finally, Higginson's rats demonstrated the same phenomenon when they first found the opened door on their right.

Dynamics of Initial Delay. That the initial delay period is an essential feature of learning is not only illustrated in the delayed reaction experiments with animals, but the dynamics of the process is also indicated by the animal's behavior. In the delay period, an incomplete behavior-pattern is created under tension that must complete itself in the actual execution of the movements. Bingham's monkeys were observed watching the experimenter place the food under a particular can.

[2] Lewis, M. Howell, "Elemental *versus* Configural Response in the Chick." *J. Exp. Psy.*, 1930, Vol. 13, 61-75.

This is the only time when the necessary co-ordination of going to the proper can *could have been apprehended.* Moreover, the animal showed in various ways an *eagerness* to proceed. This could have meant only that the pattern of movement had been *formed* in outline before the overt action took place. Then the pattern completed itself under the laws of least action and configuration. The uncompleted task had kept the animal under tension, the path for the release of which had already been determined while the animal was perceiving the position of the goal in relation to the total experimental situation.

Also, in Lewin's experiment on uncompleted tasks in the human observer, there was of necessity an initial delay before the drawing could be made. This delay determined the pattern of response for the rest of the process. When the task was interrupted it meant that the learner could not complete the pattern set up in the delay period, and therefore he was under stimulation toward a completion until given further opportunity at a later date. Here the interruption amounted to prolonging the period of initial delay.

Initial Delay in the Child. Other cases of initial delay come from observations on children. Who has not seen a child, when being told the meaning of a word, show every indication of not understanding it only at a later date spontaneously to use the word in the right context? Time is obviously required for the child to comprehend the word and to construct the perceptual-motor configuration necessary for its use. A child being taught to wave 'Good-bye' is another example. When shown how to make the appropriate movements he will not at first carry them out, but after a brief interval of time, will execute the performance correctly without practice.

Initial Delay a Criterion of Insight. It is obvious from our discussion that initial delay is a criterion of insight. The hesitation that precedes a performance, never made before, indicates that the subsequent movements are not random at whatever stage of the performance they happen to appear. It is during this period that the learner is spending the time necessary to perceive one detail of the stimulus-situation in relation to other details. A new organization of stresses in the nervous system must come into existence as a response to a number of

stimuli all imposed on the organism at once. Time is required for effecting this organization. This time is the delay period. Only when this organization is effected does the learner have insight into the problem of co-ordinating his muscles.

The Emergence of Skilled Responses

Snoddy's Analysis of Movement. Returning to Snoddy's experiment, pertinent observations were made on the emergence of co-ordinated skilled movements. The former theories of the development of co-ordination regarded skill as a fixation of motor habits, according to laws of effect, exercise, frequency and recency. Even the facts on which these theories were based would not have pointed in the direction of the interpretations given them had it been possible to see the total picture. Instead, the mechanistic suppositions with which it was customary to start determined the investigator's statements of the supposed facts. These assumptions were twofold: first, that separate, discrete random movement came first, and second, that every learning process begins with a mere trial and error procedure. With these suppositions made at the outset it was necessary to conceive some principle or law, such as the law of association (repetition) that would supposedly account for the fixation of accidentally successful movements and the elimination of the accidentally wrong ones. The unsuccessful movements were of course supposed to drop out through lack of repetition. Snoddy's analysis of mirror tracing justifies a different view *that must be true for behavior if the human being is an energy system.*

He was able to analyze minutely the movements made by his subjects. To obtain an understanding of his results it will be necessary to examine the musculature of the arm. The muscles of the arm, as in most parts of the body, are arranged in antagonistic pairs. On the back of the forearm are extensor muscles which are used in straightening the fingers; on the under side of the arm are flexor muscles which bend the fingers. On the back of the upper arm are the triceps which are extensor in character; and on the front side there are the biceps which are flexor in character.

Pattern Movements. An examination of Fig. 32 shows that the learner begins tracing a star, mirror vision, *by making simple* extensor and flexor movements. By an extensor thrust of the arm he pushes the stylus from *a* to *b* and then by use of the flexor muscles he pulls the stylus back to *c*. Superficially these might be construed as random movements which must sooner or later drop out, because they are not, apparently, directed toward a goal. According to the trial and error theory, the movement that eventually carries the stylus straight down the path *is made accidentally and is separate from the zigzag movements which we have just described.* The tracings shown in the figure prove that the successful movement is a gradual evolution beyond the so-called unsuccessful ones. It is at each step an entirely new set of movements as demonstrated by the changed direction of the paths.

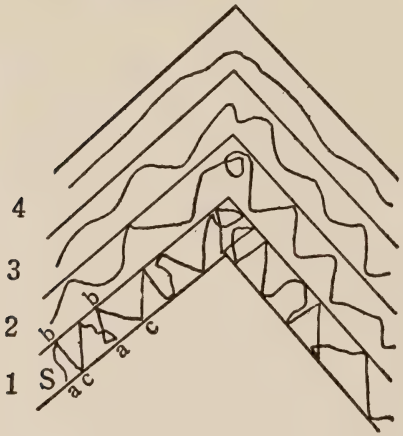

FIG. 32. REPRESENTATION OF PROGRESS IN MIRROR TRACING (Snoddy).

(1) Typical path traced by the learner around one corner of the star pattern early in the course of the learning process. (2), (3) and (4) are tracings made around the same corner at successively later stages in the learning showing the effects of a progressively better balancing of flexor and extensor muscles.

This fact is all the more obvious when we consider the consequence of contracting both the flexor and the extensor muscles at the same time. A *pattern movement* takes place in an entirely different direction from the pure flexor and extensor movements. Snoddy found that the successful movement was a pattern of this sort. The subjects learned to traverse the pathway with a straight movement of the stylus down the path when they *discovered* how to balance their flexors against their extensors. Again, 'dropping out' means 'not made any more' and that is all.

Muscular Co-ordination and the Law of Field Genesis. In this emergence of the successful movement that made use of opposed sets of muscles we find objective evidence of the law of field genesis. In the nervous and muscular system there has evolved an expanded pattern of motion that has differentiated into balanced, dynamically related contractions of two muscle groups. Parts have emerged, already integrated as they emerged. One obtains entirely the wrong impression of how motor co-ordinations develop simply by looking superficially at the pathway traversed by the stylus. The first trials show that the stylus wandered all around the path of the star. The later movements are straight and direct. Visually, it looks as if the 'wanderings' *must have been eliminated.* They disappeared from the tracings, to be sure, but this does not mean that within the nervous system of the learner, agencies were at work 'knocking' the 'random movements' from the pattern. The change came about as the learner solved the problem of making a simultaneous, complex movement where, previously, he had made several separate movements. He did not combine the separate movements previously made. He executed an entirely new movement, requiring a different type of nerve control, as a consequence of a growth process.

Pattern Movements in Golf. Golf is an excellent example of this same principle. The initial movements of the amateur are like the first movements of the star tracer. The learner follows the law of least action and reduces the problem to its simplest terms which, in matters of muscular movement, means the separate contractions of separate muscle groups, one by one. He swings at the ball as he would swing an ax, putting the force of his swing upon his extensor muscles alone. As yet, he can contract only one set of muscles at a time. Compare this performance with that of a three-year-old child, new at the task of interpreting a picture. The child sees one thing at a time, and can do no more than enumerate isolated objects.

The golfer eventually learns to do what Snoddy's subjects did. He balances two opposed sets of muscles in executing the stroke. As a consequence he strikes the ball with a pendulum swing and follows through instead of chopping into the ground. The child follows a similar plan. He must perceive for himself

the objects in the picture in their relationships to each other, before he can interpret the picture or understand an adult when the latter tells him the story of the picture. Likewise, the golfer must perceive the correctly balanced contractions of his muscles before he makes the stroke. Placing him in the right stance and showing him how to hold the club are of no avail until he, himself, understands the task.

Law of Field Genesis Applied to Golf. While at first, like the star tracer, the golfer makes movements that are inaccurate, the improvement comes in the expansion and differentiation of a unified movement-pattern. Moreover, the golfer does not learn the speed with which to swing the club, then the direction to give the ball, then the correct hold on the club, then add all these together into the proper stance and swing. Instead, he must at first obtain *a vague idea* of a total, complex act. His performance of necessity is gross at the outset. He masters various details simultaneously but at the same time gradually, as the finer co-ordinations emerge, related as they emerge, from the undifferentiated total pattern with which he commenced. Each stage of the improvement represents a new achievement, a pattern of motion never before executed. The *total act* is constantly undergoing a change, and each new phase is not accountable for in terms of previous movements any more than the straight line down the star was accountable for in terms of criss-cross movements. If an aspect of the performance fails to differentiate, the learner may segregate and vary it, until *the principle* of its rôle in the whole is discovered in a *simpler* situation. Thus the wrist-snap is 'practiced' separately in golf.

Note the resemblance of this account to our earlier description of the recognition process. The infant recognizes its mother's face, first, as a whole. The face is seen as a unified, undifferentiated, perceptual field. Later, parts like the nose and mouth emerge from the face, *but at the same time the face remains an organized, total perceptual pattern.* The child, learning to spell, must first recognize the word as a unit and then after the perceptual processes have differentiated, the letters emerge in their proper relationships. In any learning process, there is a gradual emergence of details from a 'single piece' of

motion, the 'single piece' always remaining the same general act from start to finish, an act of looking at a picture, an act of swinging a club, an act of spelling, an act of threading a maze, an act of tapping keys on a typewriter.

Motivation

An Approach to the Problem of Motivation. Another important aspect of the learning process has to do with the problem of motivation. 'Tension' is a general term that satisfies the problem of motivation. Recall that tension does not mean a 'thing by itself'; it is not a force residing in an object or in a particular place. It is a relational term denoting a difference in potential between one part of a field of energy and another part, consequently it implies an end, or resolution, otherwise it has no meaning. Thus, tension implies the existence of a unitary field of energy, in which one stress or part depends on another. Both, or all, must exist, or nothing. Tension, therefore, applied to human life, is a dynamic term, which demands a psychological description of behavior in words like 'purpose,' 'wish,' 'intention,' or 'effort toward a goal.'

If motivation is the demand of a tension for resolution, because of a differential, it no more causes learning than learning causes motivation. Moreover, increase in motivation may often lead to disastrous results as far as the problem to be learned is concerned, for it may mean the substitution of an ulterior goal.

Richter's Experiment on Animal 'Drives.' Proof of these points comes, first, from experiments which show that motivation is a matter of raising potentials in the organism. These potentials may be raised, first, through intraorganic stimulation. Recall Richter's [3] intensive study of tensions induced by intraorganic stimulation. He constructed rat cages in such a way that any move which the animal made would be recorded on a smoked drum, revolving at a given speed. Records taken over a long period of time showed that the animals' activity exhibits cycles with one and a half to two hours between the peaks of activity. These cycles, Richter found, coincided *with the*

[3] Richter, C. P., "Animal Behavior and Internal Drives." *Quart. Rev. Bio.*, 1927, Vol. 2, No. 3, 307-343.

stomach contractions of the rat. (Fig. 33.) His records give conclusive evidence that the stomach contractions and heightened bodily activity are dynamically related; that intraorganic stimulation from the stomach induces the general bodily activity. In fact, rhythms of general activity and of stomach contractions, in the rat, have three characteristics in common: (1)

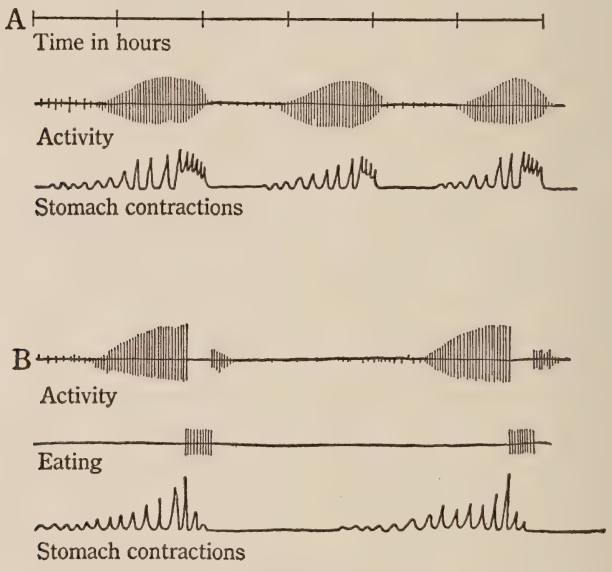

FIG. 33. SCHEMATIC REPRESENTATION OF THE RELATION BETWEEN PERIODS OF GROSS BODILY ACTIVITY AND STOMACH CONTRACTIONS IN THE RAT (Richter).

A. Simple activity cage without food. B. Double cage with food. By permission.

The frequency of both varies between one and two hours; (2) the active phases of both begin at slight intensity and increase gradually, reaching a maximum at the end; and (3) in both, the active period ends abruptly and is followed by a quiescent interval.

Further evidence of the relation between the periodic stomach contractions and heightened bodily activity was obtained by Wada [4] who studied body and stomach movements made during sleep in the human adult. When hunger records are taken

[4] Wada, G. H., "An Experimental Study of Hunger and Its Relation to Activity." *Arch. Psy.*, 1922, No. 57.

from a human being during sleep, it is found that the record of stomach contractions and body movement come at the same time. Analogous cycles appear in man, therefore, as well as in the rat, but they are of much longer duration in case of the human adult. A similar coincidence of stomach and bodily activity was discovered in infants, where the duration of the cycles was more nearly that of the rat.

It is obvious from these results why animals and human beings are more active when hungry. Stomach contractions induce heightened activity by stimulating the entire organism. Hunger tensions are set up which the animal seeks to resolve. The greater activity shown in the records is behavior taking place in the course of resolving this tension. Under the proper circumstances this behavior becomes a process of hunting for food and eating.

Richter found that there were many other sources of intraorganic stimulation that correlated with heightened bodily activity, like that of running. In the female, ovulation cycles of about four days in length correspond to periods of increased running activity. When the ovaries were removed the cycles of increased activity disappeared. If the ovaries were grafted back into the animal, the cycles were resumed. Important evidence that the ovaries were sources of internal stimulation was obtained by transplanting these organs into castrated males. Four-day running cycles appeared in their behavior. In the normal male, spontaneous activity was not definitely cyclic but depended to a considerable extent upon the existence of sex organs, for when they were removed the level of activity of the animal was greatly reduced.

Experiments on the relation of the rat's body temperature to nest building activity pointed to the fact that temperature of the body is an important source of intraorganic stimulation. At times when the temperature of the body ran low, as during pregnancy, lactation, or when the temperature of the environment was low, the rats built larger nests than at times when the body temperature was higher. It would seem that many activities of animals such as burrow digging, migrating, hibernating, and huddling together, on the one hand, and running, climbing, jumping, on the other, trace back to temperature stimulation.

The former are activities which conserve body heat and the latter are activities which increase heat production.

Other Measurements of Motivating Tensions: Dashiell. Dashiell [5] devised an experiment for the measurement of activity in rats under different degrees of hunger tension. He used a large checkerboard maze, and measured the animal's exploratory behavior by the number of intersections traversed in a given period of time. Table V shows the difference between the hungry and the non-hungry animals; the hungry rats traversed on the average nearly twice as many squares as the fed animals.

TABLE V

NUMBER OF BLOCKS ENTERED BY ANIMALS OF TWO GROUPS

Fed	Hungry
20	34
29	36
9	37
24	47
31	42
The averages for 17 rats:	
26.7	42.9

Kuo's Experiment. By means of a simple four-choice box, Kuo [6] measured the effects on learning of a short path to the food, confinement for twenty seconds, a long path to the food, and an electric shock. He used four groups of rats, and, for each group, a variation in the spatial relationships of the compartments. The hungry rat was placed at S, in Fig. 34, facing the row of doors leading into the four compartments. If the animal chose compartment 1, the experimenter opened the rear door, kept D_2 closed and opened D_1, the short path to the food at F_1. If compartment 2 was chosen he closed the front door and confined the animal for twenty seconds. If the rat chose compartment 3 he gave it an electric shock, sufficient to hurt but not to injure the animal. If compartment 4 was chosen the

[5] Dashiell, J. F., "A Quantitative Demonstration of Animal Drive." *J. Comp. Psy.*, 1925, Vol. 5.

[6] Kuo, Z. Y., "The Nature of Unsuccessful Acts and Their Order of Elimination in Animal Learning." *J. Comp. Psy.*, 1922, Vol. 2, 1-27.

experimenter opened the rear door, kept D_1 closed and opened D_2, allowing the animal to reach food at F_1 by the long alley.

Kuo's animals eliminated the electric shock compartment first, the confinement box second, the long-path third, finally choosing only the short path. *It is significant that the order in which the animals eliminated the three routes was independent of the frequency with which they had entered the compartments. It was characteristic of the animal suddenly to discontinue an undesirable pathway, obviously an insightful response.*

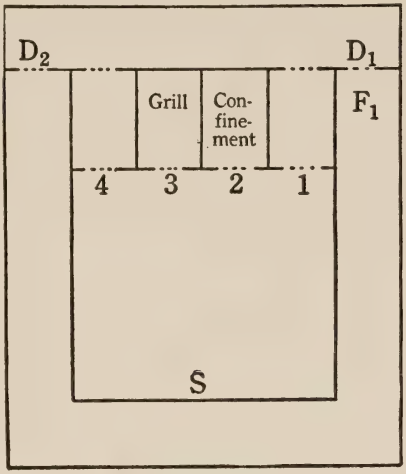

FIG. 34. KUO'S MULTIPLE CHOICE BOX FOR THE STUDY OF THE ELIMINATION OF UNSUCCESSFUL ACTS IN ANIMAL LEARNING (Explanation in Text).

A Law Pertaining to the Goal. In connection with the data collected thus far concerning learning a general law can be stated that whatever object or situation at the time relieves the most tension, or best balances the tension, is the goal which directs the organism's activities. This is a special case under the general law of least action. If a single goal is not at once operative it is because there is a conflict of goals; the right path has not yet been perceived in its entirety as the shortest path for the relief of tension. That some of Kuo's rats continued to choose the long path for a considerable time, is to be accounted for in light of certain conditions in these animals, not under control, which meant that the long path relieved the most tension or relieved the tension so adequately that the short path was never discovered as a shorter path to the goal.

Experiments on Human Beings: Kitson, Knight and Remmers. Kitson[7] measured the consequences of in-

[7] Kitson, H. D., "A Study of Workers Under a Particular Wage Stimulus." *Univ. J. of Bus.*, 1922, Vol. 1, 54-68.

creased tension in human beings in a study of the improved efficiency of forty hand compositors. After examining their output under normal conditions he measured their progress under a special bonus system and under the incentive of knowledge of daily score. Although the average trade experience of these men was 10.3 years, under the new system their efficiency increased on the average from 58 to 97 per cent in 20 weeks. One compositor of 27 years' experience made a gain of 142 per cent; another, of 14 years' experience, improved 282 per cent. These men, with the change in working conditions which gave them more insight into the task, possessed a higher tension to be relieved toward the now more effective goal.

Knight and Remmers [8] obtained similar results with college students. Ten college freshmen who had previously been hazed by their fraternity for a week and allowed to sleep only two hours a night, were given tests in addition at 10 P.M., and their results compared with the scores made by the same number of junior students of equal ability who were tested under the most favorable classroom conditions at 8 A.M. The president of the fraternity told the freshmen that they must push themselves to the limit on the tests, as the score they made would determine their final acceptance or rejection by the fraternity. The junior students were told to do their best, but had no special interest in their final scores. Under these conditions the freshmen made an average of 21 columns of addition for each five-minute period, while the juniors only made an average of 11 columns. The special motivation under which the freshmen worked not only offset the extreme fatigue produced by the hazing and the loss of sleep, but offset freshmen *versus* junior 'ability,' and in addition, produced twice as much work per unit of time, with equal accuracy.

Relation of Internal to External Stimulation. It is an error to suppose that any response of an organism is induced, alone, by internal stimulation. When the rat is excited into heightened activity by internal stimulation, as from hunger contractions, he is also receiving stimulation over other sensory channels, the eyes, nose, and ears. These modes of stimulation

[8] Knight, F. B., and Remmers, H., "Fluctuations in Mental Production When Motivation Is the Main Variable." *J. App. Psy.*, 1923, Vol. 7, 209-223.

play as important a part in producing behavior in the organism as do the internal modes of stimulation. In fact hunger *does not give direction to* the organism's movements. It merely raises its nerve potentials and thus makes it active. This energy must express itself in the line of least action, and the line of least action is determined by the character of the external stimulus-pattern in terms of which the animal perceives *where to hunt for food, and the position of the food when found.*

The same principle holds in case of sex activity. Internal stimulation does not inform the organism how to reach or to behave toward a sex object. Like hunger stimulation, it merely raises a tension that must be directed in terms of external stimulus-patterns. Like hunger, it gives to the animal's behavior only a restlessness and a hunting aspect. Similarly with responses to temperature stimulation. When the organism's body temperature is lowered, tensions rise that must be directed, through the functioning of the various senses and the total brain, into specific acts of finding and using materials for nest building, or into such acts as digging burrows. What we have just said is a lengthy statement of the law of configuration. The animal, although stimulated internally, is responding to a total situation and, although it is behaving under the incentive of a hunger, a sex desire, or a desire for warmth, the incentive is relative to the organism's insight into the total situation. A motive, irrelevant to a goal that must be perceived through insight, will never be effective.

Summary of the Learning Process. In this and the preceding chapters, data have been accumulating that point to the following important facts about the learning process:

1. Learning is a growth process.

2. The growth takes the form of maturation when regarded from the standpoint of the nervous system.

3. The growth takes the form of an evolution of insight when regarded from the standpoint of the organism's experience.

4. The growth occurs in an orderly fashion through a definite cycle from undifferentiated to differentiated response. It is an expanding, differentiating unit of behavior. Local, individuated movements, such as reflexes, do not integrate.

5. Learning is the expression of a potential.

6. This growth potential, expressing itself in maturation, differentiates under stimulation and resolves itself toward remote ends. This means that mental development is a goal-activity.

7. Particular processes of learning commence in tensions that are relative to remote ends (low potentials) and, therefore, demand resolution toward goals. Expressed psychologically, they commence with purposes that demand fulfillment.

8. The picture of the learning process is that of an undeveloped pattern of response demanding completion through expansion and individuation.

9. The energy of the learning process is derived from internal and external stimulation; the effects of the one are relative to the effects of the other. In other words, the learner is responding to a total situation and the goal is a *locus* in that situation.

10. There is no learning without the will to learn, *because the will to learn is the only factor that, in human life, satisfies the procedure demanded by the laws of dynamics.* The will to learn is the energy of the total organism conditioning the activities of its parts.

11. At no stage in the learning process is there random activity. To interpret learning in this way commits the fallacy of the double standard.

12. Each step in the learning process is organized under the law of least action. The most direct route to a given goal depends upon the alignment of stresses induced by the stimulus-pattern, and upon the degree of maturation of the learner.

13. That situation will always be responded to which best resolves the learner's tension.

14. There is always motivation in learning. Motivation is the process of raising potentials. This comes about in two ways: First, through intraorganic stimulation. This stimulation gives to learning its emotional aspect. Second, motivation comes through external stimulation in such a way that the stimulus-pattern provides a problem within the learner's level of insight. This is motivation by giving the learner understanding into the situation to which he is responding.

15. Motivation is a process of energizing and definitizing the learning process. Motives are not external to learning; they are the aspects of the more rapid and efficient learning that comes, first, with intensity of stimulation and second, with the fitness of the problem with respect to the learner's level of insight.

16. The development of the nervous system, of motility in the embryo, of motility in the infant, of co-ordination of movements in children and adults, and of perception and thinking, all follow the same fundamental set of laws.

17. There are no laws of learning that are not also laws of intelligent behavior, volition, emotion and personality.

18. Learning does not take root in instinct or drive, or in the original nature of man, as ordinarily understood, for there are no instincts or drives, nor is there an original nature of man. Man has the *same nature* when old as when young; his behavior is no different in principle at any two stages in his development. Searching for food, self-protection, and solving calculus are to be explained by the same set of laws, applied to different sets of stimulus-conditions and levels of maturation.

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CHAPTER XV

CONTROL OF THE LEARNING PROCESS—I

Whole *versus* Part Learning

Purpose of Control. There remains the problem of practical applications. What are the best ways to learn, as seen in the light of the facts that have been accumulating thus far? Remember, that regardless of any theory of learning, the learner will follow the natural laws of his behavior. Regardless of methods imposed upon him, he will learn, somehow, provided he has the will to learn. Investigators have been experimenting upon the conditions of learning for years without ascertaining the real secrets of the process. Are the secrets any more apparent now? Not wholly so, by any means. The conditions of learning must be varied more systematically in order that control of learning can be made more effective, basing procedures upon all the good that can be found in the experimental work of the past, and upon what is at present being discovered. The test of theory and of method will eventually rest in an ability to effect improvements in the learning process. Will the theory and the method work?

The present chapter and several that are to follow will be devoted to methods of engineering the learning process, and as far as possible the most effective methods will be determined by functional analysis. If, for example, our problem for investigation were the process of memorizing a poem, then we should want to know under what circumstances the learner masters the material in the shortest possible time and retains the material over the longest possible time. We should want to know how such conditions as the grouping of the material, the meaning of the material, the learner's knowledge of results, recitation, the rôle of experience, and of rewards and punishments affect the process of memorizing, and subsequent recall.

Our task, therefore, will be that of determining the relative importance of these conditions.

Whole-Part Learning. It is better to learn by the *whole method* than to divide the learning material into a number of parts. By using the whole method the learner is obtaining, in the beginning, a general conception of the entire material by reading it through. The conception is at first general and undifferentiated, but *if he continues with the whole method or some convenient variation of it, the details of the material will eventually emerge, learned in a properly interrelated fashion.* He is applying the laws of individuation and field genesis to the learning process.

It is common observation that most learners violate these principles and as a consequence are handicapped in their learning. In the first place, when the average learner attacks a problem like the memorization of a poem, he will master the first stanza, then separately, the second, and so on. The probable reason for this procedure is the illusory evidence of progress in the beginning. The learner thinks, "One stanza learned already!" In reality, however, he fails to observe that when he finishes mastering all the separate stanzas he confronts *the additional task* of uniting them into one poem, a procedure which is unnecessarily wasteful because he is now repeating passages that he has already learned in separate units.

In the second place, when the whole method is employed, the learner is able to grasp the significance of the material as one continuous narrative. If, however, the part method is used, he loses the thread of the story; it is not now a comprehensible plot, but a series of unrelated items, which he may or may not apprehend as a unit when he puts the parts of the story together. The chances are against his adequate conception of the whole, because he is by this time in a hurry to finish, and he will not discover the numerous ways in which the details of each stanza follow logically from the main theme. He has not made sufficient use of the laws of derived properties and determined action. The adherer to the part method may be able tentatively to recite a poem correctly, but he cannot give a satisfactory account of the story in his own words, or will he remem-

ber the poem very long. In fact, his recitation will inevitably give away the superficiality of his procedure.

In the third place, the whole method is superior to the part in that it permits the proper emphasis on all parts of the material, giving them the relative weight that the author intended them to have. Those who use the part method often distort the story by spending more time on parts of the material which, as far as the thread of the story goes, are relatively unimportant. Moreover, when *reciting* the material these individuals give to minor portions emphasis in proportion to the length of time which they spent on them. As a result, the portrayal is foreign to the original meaning intended by the author.

Difficulty with stubborn passages is caused originally by an inadequate conception of the whole. The consequent lack of artistic rendering of the selection is also proof that the material is not adequately understood. Few learners approach the task with the most important thing in mind, namely, to understand and to appreciate it. Instead, they are seeking the more artificial goal of memorizing the material mechanically. Little do they realize that even the memorization would have been easier had their attitude been that of appreciating the beauty of the selection as a unit. This beauty cannot possibly be perceived by the part method. And to make matters worse, the learner may leave out, entirely, certain sections of the material or confuse the order of the material, for he has missed the continuity of the passage in its completeness of related detail.

Experimental Studies of Whole and Part Learning. The first experiment to point out the superiority of the whole method over the part method was performed by Ebbinghaus [1] in 1885, who made this his first rule of memorizing. Subsequently, Ebert and Meumann [2] working on children, found that the greater the number of parts into which the material to be learned is divided, the less efficient the learning. If, however,

[1] Ebbinghaus, H., *Memory.* (Tr. Ruger.) New York: Teachers Coll., Col. Uni., 1913. (Original date, 1885.)

[2] Meumann, E., "Über einige Grundfragen der Psychologie der Übungsphänomene im Bereiche des Gedächtnisses." *Saml. von Abhandl. zur Psy. Päd.,* 1904, Vol. 1, 437-668. See also Meumann, E., *The Psychology of Learning.* New York: Appleton, 1913.

the material was meaningless, then the advantages of the whole method were not evident. Meumann held that in adults the whole method was more advantageous than the part method, even in the case of nonsense syllables (tej, yan, dib, mov), except when the learner slighted the middle sections of the material. Contrary to these results Ephrussi [3] found that the part method was uniformly better for *unfamiliar* material and the whole method superior for familiar material.

Pyle and Snyder's Experiment. Working on the same problem, Pyle and Snyder [4] presented learners with material of varying length. They discovered that the whole method was superior whether the task was 5 lines of poetry or 240 lines. In regard to the relative merits of the *size-unit* with which to work, these investigators found that the 50-line unit offered a saving of 11 per cent over the 5-line unit in amount recalled at a subsequent period; and further, that the 60-line unit furnished a saving of from 20 to 22 per cent; 120-line units a saving of 17 per cent, and 240-line units a saving of 20 per cent.

Pechstein's Experiments. Certain other investigators discovered the best way to limit the whole method, under special sets of conditions. Pechstein [5] studied maze learning and found that an unmodified whole method was not the best, but was superior to the extreme part method for the same type of task. His subjects learned a maze divided into four sections. In the first experiment they learned part 1, then parts 1 and 2, then parts 1, 2 and 3, and so on, which Pechstein called the *direct repetitive method.* In the second group of experiments they learned the maze by the *reversed repetitive method,* section 4 first, then 3 and 4, then 2, 3 and 4, and finally all four. In a third group of experiments, learning took place by the *progressive part method,* section 1 alone, then 2 alone, then 1 and 2 connected, and so on until all the material was learned. The results showed that both the progressive and direct repetitive methods were superior to the undivided whole method.

[3] Ephrussi, P., "Experimentelle Beiträge zur Lehre vom Gedächtnis." *Zsch. f. Psy.,* 1905, Vol. 37, 56-103; 161-234.

[4] Pyle and Snyder, "The Most Economical Unit for Committing to Memory." *J. Educ. Psy.,* 1911, Vol. 2, 133-142.

[5] Pechstein, L. A., "Whole *versus* Part Methods in Motor Learning: A Comparative Study." *Psy. Mon.,* 1917, Vol. 23 (No. 99).

Similar experiments were performed by the same author [6] on the task of learning poetry. The results showed that the progressive and repetitive part methods were more effective than the whole method for poetry, and further, *that learners of high intelligence were able to use the undivided whole method more effectively than persons of low intelligence.* These findings, although they place certain limitations on the whole method, substantiate the earlier results that the whole method is better with familiar material than the part method, and further, that the pure part method is inferior to the whole method.

Sawdon's Experiment. Additional qualifications upon the general superiority of the whole method have been pointed out by Sawdon [7] who worked with boys of the same level of intelligence. His results demonstrated the whole method to be superior when the memorial material (poetry) was easy, rhythmic and had a definite story running through it. In difficult passages the whole method did not prove so satisfactory. Further, if the time-limit in which to learn the material was short the part method was better, but if the time was long then the whole method excelled. When the time was neither long nor short, neither method was superior. These results would again confirm the earlier findings that when ordinary material requiring some time to learn is employed, the whole method is the more efficient, both for accuracy and amount of immediate recall, and for accuracy and amount of later recall.

Brown's Experiment. Brown [8] studied the relative effectiveness of the whole, part, and combination methods in learning piano music. The combination method was similar to Pechstein's progressive part method. The whole method proved to be the most effective for two cases out of three. When the most difficult score was learned by the whole method it ranked second of the three. The part method was the least efficient throughout. The combination method was the most effective for the easy scores, but ranked second on all others.

[6] Pechstein, L. A., "The Whole *versus* Part Methods in Learning." *Stud. Educ.*, 1926, No. 15, 181-186.

[7] Sawdon, E. W., "Should Children Learn Poems in Wholes or Parts?" *Forum Educ.*, 1927, Vol. 3, 182-197.

[8] Brown, R. W., "A Comparison of the 'Whole,' 'Part,' and 'Combination' Methods of Learning Piano Music." *J. Exp. Psy.*, 1928, Vol. 11, 235-247.

The whole and combination methods were the most effective in reducing errors to a minimum early in the practice periods.

The Mediating Method. It is evident that the whole method is in general superior to the part method, but as far as experiments have gone, the former appears to have certain limitations as the most advantageous method for particular tasks. We can accept certain of these limitations. First, the materials encountered in the ordinary classroom are rarely of the same difficulty throughout. A list of words in a vocabulary, or a poem, usually contains words or parts which are much more difficult than any of the other parts. When this is true, the learner using the whole method is compelled to continue reading the easier parts which have already been mastered for the sake of the more difficult parts which are yet to be learned. Second, one who uses the whole method, characteristically learns the end of the material and the beginning of the material first, and the central portion of the material last. It is also in the middle part that the learner usually becomes confused when reproducing the material. Obviously he has more difficult relationships to perceive in the central portion than at either end. In employing the whole method, the middle portions, however, receive the same time as the end portions and thus are not as well learned.

In order to offset these disadvantages of the whole method, a modified procedure can be introduced, called the mediating method, which is the whole method in principle, but permits proper emphasis of time upon the difficult passages.[9] There are two general types of mediating methods. First, if the material is relatively non-coherent, like a group of nonsense syllables or a vocabulary in a foreign language, the learner should read the series of words or syllables continuously until he observes that certain members of the list are more difficult than others. Then he should indicate these words by a special mark, devote special time to learning them, and return to the reading of the whole, proceeding until the whole is uniformly mastered. This variation of the whole-procedure makes for efficient learning of material that is not uniform in difficulty.

The second mediating method is the division of a given set

[9] Meumann, *op. cit.*

of material into parts on the basis of relative difficulty. These parts may be separated by marks or by blank spaces. The learner then reads the series continuously, but *pauses* at the end of each division, and thinks about what he has learned thus far. He *does not return* to the beginning of the section as in the first method; instead, he continues through the next division and so on to the end. A variation of this same type is the division of the material at *logical* breaking points, after which the parts are studied in the manner just described.

There are cautions to be observed in the use of the mediating method. First, the learner should not lose sight of the fact that the parts are divisions of a larger unit of material which has valuable meaning in its own right; and second, he should not attempt to repeat the divisions *separately.* This way he wastes time and accuracy in relating them later. The mediating method is obviously the procedure to adopt with material that is of extreme length, such as a sonata, a part in a drama, or a long speech. The fact that the divisions made in employing the mediating method should always be learned with respect to their significance for the *entire mass of the material, means that this method is the whole method judiciously applied.*

Comments on the Preceding Experiments. There are limitations placed upon the whole method by many of the investigators whose results we have just reviewed. The part method seems best for learners of lower intelligence and for material whose difficulty is greater than the learner's ability to grasp its significance. It is also better, in some respects, for noncoherent, or relatively senseless material. But the fruitlessness of drawing conclusions as regards the learning process from results like these should be obvious. First, learners of low intelligence (outside of institutions for the feeble-minded) should not be presented with tasks which, as units, are beyond their grasp. Second, there is no excuse for imposing upon students of average intelligence or better, learning material that is beyond their ability to understand, when it is a simple matter to avoid such a difficulty. It only means that poor judgment has been applied in fitting the task to the learner's level of maturation and insight.

Third, it is hardly sensible to suppose that results of im-

portance can be obtained from investigations on noncoherent and senseless material when, if there is anything that should not be learned either in daily life or in the classroom, it is noncoherent subject matter. One cannot justify the applications of results from investigations of artificial material. While it is true that the laws of learning must be the same for senseless as for meaningful material, the circumstances of their application will of necessity be different. It is to be concluded, therefore, that investigations carried out under conditions not actually penalizing the learner, have demonstrated the superiority of the whole method and its variation, the mediating method. Furthermore, it may be concluded that, strictly speaking, the *'part method' is an illusion.* Under no circumstances does learning take place, psychologically, by this method. On the contrary, the learner masters the task in spite of the part procedure imposed on him, rather than because of it. He must in some way apprehend the task as a unit and subordinate the parts to the whole.

M. Cutsforth's Experiments. This point was brought out by Cutsforth in her experiment on chicks.[10] She satisfied the experimental conditions for the part method of learning and found *that her chicks of their own accord adopted the whole method.* Her procedure was to train a group of chicks, at the outset, on a single bank of lights. Then she added a second bank in front of the first. If the chicks' natural method of learning had been that of mastering segregated and unrelated parts, they would have required as much time to master the second bank as the first, but this was not true. They not only learned the second bank more readily than the first, but, by the time the third bank was introduced, they were able to master it almost at once. In the case of each bank, the task was different. In the first the brightest doorway was correct. In the second, it was the medium, and in the third it was the dim. Under the conditions of the experiment, no place habits could be formed. The fact that there was progressive improvement throughout the experiment showed that each part was being learned in the light of the whole.

[10] Cutsforth, M. G., *op. cit.*

Length of Material and Speed in Learning

Length of Material in Relation to Learning. Length of material, or size of the task, is an important factor in the control of the learning process. Will the learner require the same amount of time to master a given unit of work when it is part of a long task as he does when it is part of a short task? And will the two tasks as wholes be retained equally as well over a given length of time? These are the major questions with which we shall be concerned in this section. Ebbinghaus first investigated the problem. He found that with one reading of nonsense syllables, he could recall 7 syllables; 12 syllables took 16.6 readings, and 16 syllables took 30 readings.

Lyon's Experiment. Lyon,[11] working on the same problem, used nonsense syllables, digits, poetry and prose. He not only compared length of material with the time spent in learning, but varied the method of learning in order to ascertain which method was best for materials of different length. For example, he introduced a continuous reading method and a 'one-a-day' reading method. In general he concluded first, that the time consumed by the 'once-per-day' method varied directly as the length of the material; second, that when the 'continuous' method was used this relation of time and length holds only for the shorter passages and that with materials of increasingly greater length the time mounts rapidly. Thus, although it took only 5 minutes to learn 24 digits, it took 2 hours and 34 minutes to learn 200 digits, which was now more than 31 times as long, instead of 8 times as long. This fact must mean, Lyon observed, that when the length of the material is too long for the observer to grasp the passage as a unit, the time mounts very rapidly. That this was true for the continuous method and not for the 'once-per-day' method is no doubt due to the fact that, with continuous work, the learner is given no opportunity to mature with respect to the problem and therefore can perceive very little more of the material as the readings are continued. On the other hand, when the readings are distributed

[11] Lyon, D. O., "The Relation of Length of Material to the Time Taken for Learning, and the Optimum Distribution of Time." *J. Educ. Psy.*, 1914, Vol. 5, 1-9; 85-91; 155-163.

the learner matures during the intervals to the extent that he can perceive more of the material each time he re-reads it.

Robinson and Heron's Experiment. More recently Robinson and Heron [12] performed an experiment on the relation of the length of material to rate of learning. Lists of 6, 9, 12, 15 and 18 nonsense syllables were presented to 10 subjects. Fig. 35 shows the learning curves for the lists of different lengths when the total number of syllables presented was taken as representative of learning time and plotted against the number of syllables anticipated correctly. On the average, in the six syllable list, the observers were able to anticipate five syllables correctly by the time 25 syllables had been presented, a perfect score under the conditions of the experiment. A total of over 100 syllables had to be exposed for attainment of a perfect score in the nine syllable list.

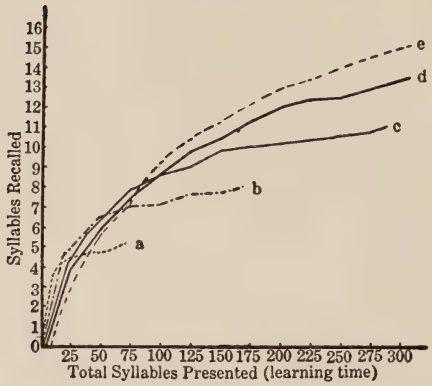

FIG. 35. CURVES SHOWING THE INFLUENCE OF AMOUNT TO BE LEARNED ON THE RATE OF LEARNING (Robinson and Heron).

a is the curve for the six-syllable list, b the nine, and so on.

The results of this experiment showed that, with the long task, more efficient methods must be employed by the learner before the material can be mastered. The longer material necessitates a noting of more relationships than the shorter material, and is thus more difficult to learn. It is obvious, therefore, that the learner must mature at the same rate with respect to the longer problem as he does with respect to the shorter one, if the two are to be learned in relatively the same length of time. But the proper rate of maturation is not possible when the continuous method is employed.

The same fact is substantiated, further, by the results from

[12] Robinson, E. S., and Heron, W. T., "Results of Variations in Length of Memorized Material." *J. Exp. Psy.*, 1922, Vol. 5, 428-448.

Lyon's experiment where, with the continuous method, a much longer time per word was required for the long task than for the short one. In both experiments progress at the outset was slow in the long task, indicating that the learner must perceive a certain pattern in the material before he can make progress, and, in the case of the long material, that the relations perceived are much more extensive and difficult. In case of the longer material, this pattern is of a more abstract character, because of its greater intricacy, which means that the learner must not only be more mature, in order to perceive the relations, but must use more efficient methods, such as the whole method, in order to perceive the relations at all. Thus it follows that the more lengthy material, learned under these conditions, will be retained better than the shorter lists, (1) because of the better methods employed in the learning, (2) because *pattern of relations* is emphasized, rather than individual, isolated items, and (3) because there is apprehended a larger whole in which the parts are learned. *Long assignments, if capable of being perceived as logical wholes, are better than short assignments.*

Rapid and Slow Learners: Lyon. Closely related to the problem of the length of material is length of time spent in learning a given task. Will the learner who masters the task rapidly retain the learned response for a shorter or a longer period than one who learns the task more slowly? Experimenters seem to agree in general that the rapid learner is also the one who retains the material longer.

Lyon[13] performed an extensive study on the relation of rapidity of learning to retentiveness. He presented college students, high school students, grammar school children, convicts, and insane patients with digits, nonsense syllables, words, prose and poetry. He employed three methods. First, the subject was allowed to study the material as long as he wished and then was required to write it down correctly. After a time interval from 1 day to 10 weeks had elapsed, the subject again reproduced the material in writing. Second, the material was learned as in method 1, but just before reproduction, the material was read aloud to the subject; then he was asked to repro-

[13] Lyon, D. O., "The Relation of Quickness of Learning to Retentiveness." *Arch. Psy.*, 1916, No. 34.

duce it from memory. Third, following method 2, the subjects were given the original material with the instructions to spend as much time as necessary in relearning it. Time spent was an indication of retention.

Lyon concluded first, that with *all* the materials, except the digits, *those who learn quickest forget the least.* Second, the quickest individuals learn the material more *as a whole* than the slower learners. Third, those who learn quickest also retain the best when the material is *logical* in character. Where the material is 'illogical,' as in the case of nonsense syllables, the quick learner also retains the most.

Learning of Different Types of Material

Rote-Logical Learning. While we were discussing the best method of learning, a question came up repeatedly pertaining to the relation of kind of material to efficiency of method. Our next problem will be that of isolating this factor in the control of the learning process. 'Kind of material' naturally falls into two divisions: (1) relatively meaningful and (2) relatively meaningless. As we have seen, the whole method was less adapted for unfamiliar material and meaningless tasks than for meaningful material. Obviously the whole procedure is inadequate for meaningless tasks on account of their lack of logical unity, which means that they cannot be apprehended as logical wholes. 'Meaningless' characterizes a situation where there are a number of logically unrelated parts. In order to master the entire task, the learner must rely on the less meaningful relationships between the parts, such as the temporal and the spatial.

The Learning of Meaningless Material. Ordinarily the whole method makes use of logical unity and continuity in the material. This is impossible where there is none. Consequently, when the whole method is employed with noncoherent material, time is wasted looking for meaning. The so-called part method eliminates this waste and permits the learner to concentrate upon the simpler task of perceiving the parts in their bare, space-time relationships in a unified space-time whole, like a series or column. This is precisely how nonsense

syllables are learned. There is nothing lost in not looking for logical relationships because there are no whole-part relationships of this character to be missed. The coherency present in terms of spatial *position* and *order* of the parts is so simple that it is grasped by the learner but not recognized as such at the time. Nevertheless this very coherency of position and order explains the learning of meaningless material. The learner has not, in actuality, been learning by the part method, although he intended to!

Bryan and Harter's Experiment. One of the first observations on the advantage of meaningfulness of material for the learning process was made by Bryan and Harter [14] on 'sending' and 'receiving' the telegraphic language. When experts were questioned concerning the relative speed with which they could receive meaningful material, disconnected words, and lists of figures, they reported that they could hold in mind 40 to 60 words of the Morse code, each word a group of dots and dashes, when the material 'made sense,' but only 3 or 4 if the material was disconnected. One expert reported, "When I get a word indicating that a list of figures is to follow, I sweat blood until I can catch up." He could wait for 6 figures if they were in groups of three separated by a comma, but if the figures were isolated he was lost when behind by more than 3 or 4 groups of dots and dashes.

An Experiment in Rote-Logical Memory. The effect of meaningfulness on the learning process can be demonstrated by a simple experiment with the materials of Table VI. The first list contains three-letter nonsense syllables, the second list three-letter meaningful words, and the third, words of four letters or more all related to one object. In general these three lists are learned as follows, when number of repetitions of the list is the measure of the rate of learning: List 1 takes 12 repetitions (about 6 minutes); list 2 takes 4 repetitions (2 minutes); but list 3 requires only one repetition (15 seconds). The nonsense syllable list must be learned almost mechanically, by rote. It is not, however, a blind repetitive process which enables the observer to learn this list. A given syllable is learned as the

[14] Bryan and Harter, "Studies in the Physiology and Psychology of the Telegraph Language." *Psy. Rev.*, 1897, Vol. 4, 27. Also 1899, Vol. 6, 346.

first, the fourth, the fifth, or the last in the series, as the case may be. It is only when the learner can perceive these spatial and temporal relationships, involving the column or series *as a whole,* that the list is mastered. This limitation of whole-part relationships in the material conditions the large number of stimulations necessary before the list is learned.

The learner proceeds much more rapidly with the second list. Here he perceives the words in spatial relationships, but in a great many other relationships as well. As each word is

TABLE VI

gub	cow	room
tej	sun	floor
soh	fir	wall
biq	pet	ceiling
maf	tan	door
cug	boy	window
por	lip	chair
vel	tub	table
wix	red	couch
yan	has	pillow

presented he recognizes it as familiar and thinks of the objects represented. In turn these objects are parts of a larger, meaningful whole not represented in the column. They are objects, or animals, or belong to some other classification which gives them membership-character in the same whole. As a consequence of perceiving these wider relationships the learner is able to master the list more rapidly. Time is saved even in reading the words. In fact the meaningfulness and the speed with which the material is perceived are two properties of the same response.

The third list is learned in one repetition, despite the fact that all of the words are longer than any in the other two. What is the difference between this and the list preceding it? Both contain meaningful words. In addition to their meaningfulness, the words of list 3 are all related to *one* object or event. *The list has a definite logical unity.* Logical unity means logical pattern, or *form,* or plan. This means that there is much more to the list than the mere individual words plus

their individual meanings and spatial relations in the column; there is also a general plan running through that makes each word follow easily from every other. A whole has given meaning to the parts.

The Rôle of Form in Learning: Guilford. The importance of form, or plan, or pattern in learning introduces a third general type of material to be encountered in a study of the learning process. The first type was nonsense or meaningless material, in which the only relationships were spatial and temporal; the second type of material consisted of meaningful, relatively unrelated items. However, there were abstract relationships to be found between each item besides the space and time relations. The third type is material with *definite* pattern or form. The experiment just cited illustrated the importance of this kind of material for efficient learning. Its importance merits further demonstration.

The rôle of form in learning was investigated by Guilford [15] with series of numbers. He constructed three groups of these series, on the order of the series in Table VII.

The first group, called the 'Y' series, was comprised of six columns of numbers arranged according to a particular numerical progression. Six other series, called the 'X' columns, were devised to correspond to the 'Y' series in length and type, but contained no plan, or 'formal' character. The third group called the 'Z' columns was constructed according to the plan used in the 'Y' series but with different items. The lists of numbers in the 'X' and 'Y' series were presented alternately with the instructions to learn the lists as quickly as possible. A reproduction of the list was called for at the end of each repetition. The 'Z' series was presented with the instructions to look for the form or plan, but before it appeared, to proceed with the learning in the usual way.

Guilford was concerned with the following problems: Does the emergence or discovery of form facilitate learning? Does failure of form to emerge, when it is expected, interfere with learning? Is there a transfer of learning in the case of certain forms? In answer to the first question, his results showed, first,

[15] Guilford, J. P., "The Rôle of Form in Learning." *J. Exp. Psy.*, 1927, Vol. 10, No. 5, 415-423.

that in every case the 'Y' series, or those that contained form or scheme, were learned in a shorter time than the 'X' series, which contained no plan. The 'X' series was learned with an average of 3.2 repetitions, while the average repetitions for the 'Y' series was only 1.4. The presence of form or pattern means, then, more efficient learning. When form is present there are more obvious relationships to be perceived than where there are

TABLE VII

MEMORIAL MATERIAL FOR FORM EXPERIMENT

Y	*X*	*Z*
6	3	8
7	4	7
9	8	9
12	11	6
16	20	10
21	25	5
27	30	11
34	33	4
42	49	12
51	59	3
61	66	13
72	73	2
84	89	14
97	92	1

only the spatial and temporal relations as in the logically non-patterned material.

In answer to the second question, when the *expected* form failed to emerge, the effect on learning was definitely brought out. When the 'Z' series was given under instructions to watch for form, and the form failed to emerge, the average number of repetitions was 4.25. Thus, where the form failed to emerge when it was expected, the learning was nearly four times as slow as when form did emerge (1.4). Indeed, learning was slower than in the series in which there was no form. The interference which occurred when the expected form failed to emerge meant that the observer had the goal at the outset to find form as a means of learning the series. Consequently, form failing to emerge, he was left with an unresolved tension. This

placed him in a dilemma because his effort was directed toward a goal that the experimental situation did not furnish. The response could not be completed, therefore, until another goal was set up, with its own tension, a process that required additional time. The *other* goal was to learn the material *without* looking for form.

Third, a transfer effect from one series to another was indicated in several ways. In most cases the number of repetitions for the 'Y' series was greater than for the 'Z,' which contained the same forms as the 'Y' series but with different items. This means that a new form which has like plan but different detail, as compared with an old form, is more easily perceived than the old form. It is like a melody changed into a different key, it is still recognized as the same melody, and easier to perceive.

Moreover, form, in these columns of numbers, was not the sum of so many parts. It was a whole that governed the status of its part and possessed the same field property in both the 'Y' and 'Z' series. This fact was demonstrated by the reports of the observers who made typical observations like the following: "Why, I have learned this plan before, but the members are entirely new."

The Emergence of Form. Guilford observed four general steps or periods in the emergence of form. First, as the learner commenced to study a given series there was a feeling of regularity or order about its construction. There is a general, undifferentiated experience which comes first in the observation of form. The learners reported that there 'were glimmerings of a scheme all the way through,' but they could not describe the scheme. But, undifferentiated as it was, the plan was capable of being followed.

Second, there was an awareness of a *direction* in which the plan seemed to evolve. The learners would report that, "the numbers were arranged in order of descending quality"; but they could give no details of the scheme with which the numbers were arranged. Third, the specific nature of the direction emerged. "I noticed that the numbers were coming in a regular progression; they went up," is a typical report during this phase of the emergence process.

Fourth, the specific interrelationships of the individual members became very definite. The observers now reported that, "the second number is two more than the first; the third is three more than the second; the fourth is four more than the third." The plan had completely differentiated, and the detailed relationships of the numbers *had emerged together.* The final ordering of the numbers *came with a flash.* Indeed, each step in the emergence process came about suddenly, as a completely organized experience. It is true that the original, undifferentiated apprehension of the form contained far less detail than the later stages, but it was a perfect and completed plan that had been 'sensed.' The last stage, no better organized, brought out the finer relationships of detail that made possible an easy mastery of the series.

Summary: Applications to Education. The following conclusions, pertaining to kind of material as a condition of efficient learning, can be drawn from the preceding experiments. First, meaningless material requires the longest time to learn, and at best is learned very poorly. This means that a problem of any kind should be as meaningful as possible to the learner. Second, meaningful material, which contains relatively little *form* (meaning), is learned more rapidly than nonsense material, but less rapidly than material which has some form. Third, material which has a definite plan running through it, or *logical form,* is learned the most rapidly of all. Fourth, failure of form to emerge, when expected, is detrimental to the learning process. This means that form should be as explicit as possible and deliberately explained to the learner in the beginning. It means, further, that *generalities,* comprehensible to the learner, should be presented *first.* Particulars will then be learned without effort and without memorizing, under the law of derived properties. Fifth, the more obvious the form the more rapidly the learning takes place. Sixth, the emergence of form passes through a definite cycle: (1) a general feeling of regularity, plan, or principle; (2) a general awareness of the direction in which the plan is to be worked out; (3) the specific nature of direction; and (4) the specific interrelationships of details.

This cycle explains why, in giving instructions, the *general nature* of the material must be explained *first,* at the level of the

learner's insight. The natural method of learning is to begin with an undifferentiated whole and proceed toward mastery of detail. Once more Coghill's work on the functioning of the nervous system finds application in the field of human learning. The order of progress is from the whole to its parts through expansion and individuation.

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CHAPTER XVI

CONTROL OF THE LEARNING PROCESS—II

Learning and Recitation

Recitation: Kühn's Experiments. Continuing a study of the conditions for optimum learning, the next factor that may be selected is *recitation.* Does the most rapid progress take place when the learner recites the material at various intervals during the learning process? Extensive experiments on this problem were performed by Kühn,[1] who presented his subjects with three kinds of material: (1) vertical rows of twelve nonsense syllables, (2) vertical rows of twelve one-syllable substantives, and (3) short verses. The subjects were divided into two groups, one in which they merely read and reread the material until confident of mastery, and another in which they were allowed to employ recitation whenever they desired. The recitation groups were in general superior under all three conditions. The effectiveness of recitation was not, however, uniform throughout the experiment. It was most effective for nonsense material; that is, the more senseless and less connected the material the greater the advantage of recitation over reading. The superiority of the recitation group was next greatest where the material was lists of words, and least in case of the verses. Tempo of learning was also introduced as a factor in this experiment, with the result that the advantage of recitation was greatest where the learner employed *his own tempo,* or natural rhythm, than when the tempo was controlled by the experimenter. Where the reading method was employed, alone, the subjects were unable to judge when the material was mastered, and often made a premature attempt at recall.

At the end of twenty-four, forty-eight and ninety-six hours

[1] Kühn, A., "Über Einprägung durch Lesen und durch Rezitieren." *Zeit. f. Psy.,* 1914, Vol. 68, 396-481.

the material was relearned, with the same methods as used in the original learning. The results again indicated the advantages of recitation, for the material thus acquired was retained much better. Moreover, recall delayed for twenty-four hours was benefited more by recitation than recall that followed shortly after the original learning.

Time of Recitation: Witasek's Experiment. Should the learner read the material through several times before he starts to recite or should he begin reciting immediately after the first presentation? Witasek [2] gave his subjects lists of nonsense syllables to learn, ten pairs to the list. In one case, the reading group, the learner read the list aloud. In the other case, the recitation group, the first syllable of each pair was spoken by the experimenter while the learner, if he could, recited the second member of the pair. The results, after six, eleven, and sixteen readings, showed a superiority of recitation over reading, as measured by the time required an hour later to recite the entire list in ten seconds or less without being prompted. The recitation group learned the material 60 to 90 per cent more efficiently when learning was measured in number of repetitions; 61 to 87 per cent more efficiently in terms of seconds; and 60 to 100 per cent in terms of number of necessary promptings. Witasek found that the reading method was subject to the law of diminishing returns. That is, the value of sheer reading declined very rapidly after the first six repetitions. Recitation was the better method of repetition from then on to the eleventh or sixteenth repetition, when it, too, followed the law of diminishing returns. Because reading proved to be a poor method of learning, the reading group began almost at once partly to read and partly to recite. They made their reading more like a recitation. This cut down the advantages of the recitation group over the reading group. Hence recitation is probably more of an advantage in learning than Witasek's figures show.

Witasek also studied the relative effectiveness of combining reading and recitation in different ways. Effectiveness was measured by the time consumed in each of five successive recita-

[2] Witasek, "Über Lesen und Rezitieren in ihrer Beziehungen zum Gedächtnis." *Zeit. f. Psy.*, 1907, Vol. 44, 161-185; 246-278.

tions following an hour after original learning. The recitation was controlled by exposing the first member of each pair, while the observer responded with the second member. Much to the astonishment of the experimenter, a small number of repetitions (6 or 11), made previous to the hour interval, was as good as a much larger number (16, 21, or 26), for the recitation that was now requested. This result shows that 'repetition,' as such, was not an advantage in learning.

During these five recitations the reading group became progressively worse, while the recitation group became progressively better. The best results were obtained when the original period of work included about 25 per cent of the total learning time and when about half of this total time was devoted to reading and the other half to recitation. Recitation was ineffective if it occupied more than fifty per cent of the total time during the first period of study. Later the effective proportion progressively increased.

Gates' Study of Recitation. A more comprehensive study of recitation was made by Gates,[3] who attacked the problem from the schoolroom standpoint, working with school children, under schoolroom conditions, and with schoolroom methods of attack. The subjects varied in age from six to seventeen years, some of them college students. The material used was of three kinds: (1) senseless, (2) unconnected material, and (3) connected meaningful material in the form of biographies. The length and difficulty of the material was suited to the ages of the learners, as determined by preliminary experiments. The subjects were divided into squads of seven or eight who remained in the same squad throughout the series of experiments. A squad was tested but once on a single day. The school children were presented material for reading and then, at a given signal, they were asked to recite. Many combinations of time spent in reading and in reciting were used. At the end of the work period the learners were asked to reproduce the material from memory, and again three or four hours later.

When 80 per cent of the time was devoted to recitation and

[3] Gates, A. I., "Recitation as a Factor in Memorizing." *Arch. Psy.*, 1917, Vol. 26, No. 40, 1-104.

20 per cent to reading, the recitation method proved twice as effective as the reading method for nonsense material. There was, throughout, an increase in the amount learned as the relative amount of recitation became greater. Retention tests made after three or four hours gave results similar in general to tests performed immediately after the study period, but with the important difference that the superiority of the methods involving recitation increased. In general the best results with the meaningful material were obtained by introducing recitation after about 40 per cent of the time had been devoted to reading. This optimum combination of reading and recitation showed a superiority of 30 per cent over reading alone. The lower grades showed a greater superiority with this optimum combination than the upper grades. The upper grades learned more effectively when the method involved a relatively large amount of reading. The optimum combinations increased in superiority, over the poorer combinations, for delayed recall. In the experiments performed on adults, with nonsense material, the results were in general the same as with the children.

Barlow's Experiment. Barlow[4] also has recently worked on the problem of recitation. He presented 327 subjects with two twenty-word lists of three-letter syllables that conveyed no obvious meaning, the syllables exposed singly. The subjects ranged from the second to the ninth grades, in addition to 51 college students. The words in an A-list of syllables were vocalized by the subjects when they were learning them; those in a B-list were not vocalized. One-half of the subjects learned the A-list first and the other half the B-list first; then the groups were reversed. The average results from all groups showed that the syllables were more economically learned when complete articulation was employed. Memorization was not more accurate, but *easier* with articulation than without.

Summary of Results on Recitation. First, methods which employ recitation are always superior to methods that allow reading only, regardless of the kind of material. Second, the superiority of recitation is greatest in nonsense material,

[4] Barlow, M. C., "The Rôle of Articulation in Memorizing." *J. Exp. Psy.*, 1928, Vol. 11, 306-312.

less in lists of disconnected words and smallest in connected material. Third, material learned with recitation is more easily relearned and more adequately retained. Fourth, the subjects who are deprived of recitation attempt to make the reading a recitation as the learning process continues. Fifth, a small number of readings is nearly as effective for a recitation as a much larger number, and in addition much less fatiguing. Sixth, increase in the amount learned is proportional to an increase in the relative amount of recitation up to a certain optimum combination for a given kind of material. Seventh, for optimum results with nonsense material, about 80 per cent of the time should be devoted to recitation; in meaningful material the proportion is about 60 per cent. Eighth, the value of recitation is not fully evident until the learner makes a delayed recall.

Value of Recitation Explained. The value of recitation can be explained as follows: (1) It compels the learner to be active in a learning-situation; it gives him a definite goal and organizes his mental processes to that end. Nothing is adequately learned when only memorized; it is mastered only when it can be expressed by the learner in his own words, or when his own feelings are put into the recitation, as in case of a poem. (2) Recitation places the learner in a social situation, which is a motivating factor. (3) Recitation furnishes additional avenues of stimulation, such as auditory and verbal. (4) It permits the learner to measure his progress. In short, recitation applies the laws of dynamics; the law of determined action, because it throws the learner more actively into a process of controlling his ideas; the law of field genesis, by giving the material a better opportunity to expand in meaning; the law of increasing energy, by motivating the learner and bringing him nearer to his goal; the law of configuration, by compelling him, for adequate expression, to perceive the details of the material in a greater number of relationships.

Control of Learning Through Control of Goal

Knowledge of Results. The next condition to be studied is the effect of knowledge of results on the process of

learning. Will the individual be more efficient in his learning if he knows what progress he is making or will that knowledge of progress be detrimental? An experiment by Kitson, already described, indicates the answer. Hand compositors of an average experience of 10.3 years made a mean gain in output of 67 per cent in 5 months under the influence of a special bonus system and knowledge of their daily score. These men made this improvement in spite of the fact that they had worked at the trade as long as 27 years.

Book and Norvell's Experiment. The most extended study of this character was carried out by Book and Norvell [5] on 124 college students. They presented their subjects with four types of problems: (1) To improve in the simple muscular act of drawing the small letter 'a' as accurately and as rapidly as possible; (2) to locate and cross out certain letters in a uniform list of disconnected Spanish words; (3) to substitute letters for a page of digits in accordance with a key at the top of the page; (4) to multiply mentally one two-place number by another. Practice periods were given 3 times a week. In the first experiment twenty-five trials were given on each day; in experiments 2, 3 and 4, fifteen trials were given each day. A seven-day interval elapsed between the end of one experiment and the beginning of the next.

The subjects were divided into two groups throughout the four experiments: First, the experimental group, in which the members were not only instructed to count their scores, but were given other special incentives for improvement; second, a control group, in which the members were kept in ignorance of their score during the experiment. In experiment 1, the experimental group counted the number of 'a's' that they had drawn, and, after each trial for the first 50 trials, placed the number in a prominent place at the top of their sheet. At the end of this period, for the next 25 trials they were not allowed to see their results. The control group, on the other hand, was not allowed to see how many 'a's' they had crossed during the first 50 trials, but during the last 25 were given their scores at the end of each trial.

[5] Book, W. F., and Norvell, L., "The Will to Learn: An Experimental Study of Incentives in Learning." *Ped. Sem.*, 1922, Vol. 29, No. 4, 305-362.

The results from this experiment showed conclusively that the groups who were permitted to measure their progress with the knowledge of results made the most rapid and continuous gains. But when they exchanged places with the control groups they suddenly ceased to gain. Knowledge of results had been deprived them. Fig. 36 shows the rapid progress of the experi-

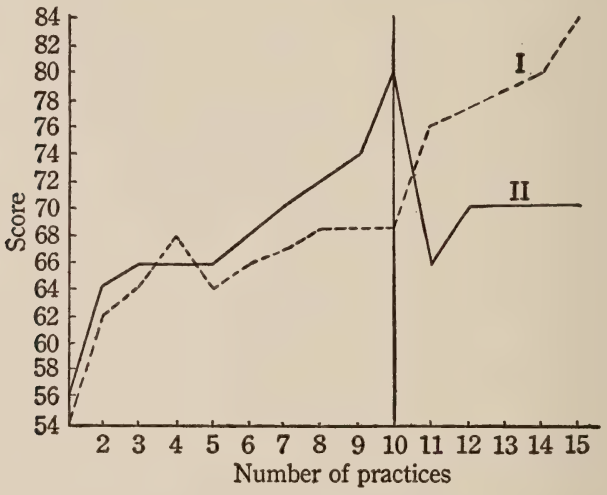

FIG. 36. LEARNING CURVES SHOWING THE EFFECT OF KNOWLEDGE OF RESULTS (Book and Norvell).

At the tenth practice the incentive was taken away from the experimental group (II) and given to the control group (I). Notice the decline in the performance of the experimental group and the sudden improvement in the control group.

mental group (Group II) up to the time the knowledge of results was removed, then its rapid decline, with little improvement during the remainder of the experiment. The control group that started without knowledge of results (Group I) made less gain than Group II, but when they had access to their results, two-thirds of the way through the experiment, their rate of progress suddenly improved and their efficiency continued high to the end of the experiment. These results were true not only for the groups taken as a whole but also for all individuals.

Not only speed but accuracy was benefited by knowledge of results. The records of the experimental group contained fewer mistakes than did the records of the control groups. The for-

mer group became careless and made many errors when working without knowledge of results. When the original control group was given the special incentives, *its accuracy suddenly improved.* These results held for all four types of tasks.

Practical Applications to School Situations. It is evident that knowledge of results is an important condition for efficiency in the learning process, a fact that is highly significant for educational procedure. First, it means that other things being equal, the child should know the extent of his daily achievement. If he is learning to spell, his papers should be corrected and handed back to him with the score in a prominent place. Second, the child should be given indication of his improvement aside from his daily score. In the case of spelling this can be done by records on the wall of the classroom or with a personal chart by which the pupil can follow his score. Third, the pupil should always know his *highest* score, in order that, should his rate of progress be declining, his goal can be made more definite. Knowledge of highest score is also an incentive for *pacing.* Fourth, the pupil should understand that he can at any time improve faster than the record indicates. Other high scores made by members of the same or different groups can be pointed out to him in order to stimulate further improvement.

This aspect of stimulation through knowledge of results and the results of competitors was illustrated by Rose Fritz who won the world's typewriting contest in 1906 by writing 82 words a minute for one hour.[6] After the contest she told Mr. Kimball, the director, that she had reached the human limit for this type of work. Mr. Kimball, however, convinced her that her record could be surpassed. As a result, when she competed again, the following year, she did surpass her record by writing 87 words a minute for an hour; the year following she raised her record, again, to 95 words. Even this was below the limit of human achievement, for, in 1924, Albert Tangora wrote at the rate of 147 correct words a minute for the same length of time.

It is plain that knowledge of results has a profound effect on interest in the task. It acquaints the learner with his dis-

[6] See Book, W. F., "How to Develop an Interest in One's Tasks and Work." *J. Educ. Psy.,* 1927, Vol. 18, 1-10.

tance from the goal. Unacquainted with his progress, he concludes that he is making none, and of course, loses interest. Not only this, but he supposes, prematurely, that maximum efficiency has been achieved. Then, naturally, he makes no attempt to improve. In short, knowledge of results stimulates progress by vitalizing and definitizing the learner's goal. The processes of expansion and differentiation, essential for learning, are speeded up under a *higher tension* that brings with it *greater insight* under the law of increasing energy.

Experiments on Motivation

Methods of Motivation: Rewards and Punishments. It has already been indicated that motivation is one of the most important conditions of learning, and it has been defined as increasing the tension under which the individual learns. It is an important subject of investigation because the learner frequently possesses an insufficient amount of energy, under the existing conditions, for the effective completion of the task. His energy must, therefore, be raised. The problem is how to do it. Just when should the learner be given increased motivation and should that motivation come in the form of reward or punishment, social stimulation, knowledge of progress, or as a change in the learner's attitude toward the task? These are some of the questions that must be answered before the learning process can be brought under complete control.

Bunch's Experiment on the Influence of Punishment. The use of rewards and punishments is the first method of motivation to be examined. The effect of pain on the learning process was studied by Bunch [7] by giving electric shocks to human subjects while they were learning a maze. There were 80 subjects, 40 men and 40 women. The results showed a decided decrease in the number of trials required to learn the maze when a shock was given on the *wrong* response. This decrease amounted to 50 per cent over learning without the electric shock. The results also demonstrated a decrease of approximately 30 per cent in the total time and number of errors when

[7] Bunch, M. E., "The Effect of Electric Shock as Punishment for Errors in Human Maze Learning." *J. Comp. Psy.*, 1928, Vol. 7, 343-359.

the electric shock was used. There was also a general increase in the efficiency with which the subjects traced the maze. There was, however, an increase of about 34 per cent in the time per trial and *an increase in variability* in the time required per trial. Hamilton [8] found in a study on discrimination that there was little difference in accuracy whether the subject was punished or rewarded.

Vaughn and Diserens on Punishment. Vaughn and Diserens [9] determined the relative effects on learning of three intensities of electrical punishment. Thirty-two subjects worked on a stylus maze in which electric shocks were automatically administered as a punishment for errors. Efficiency was measured in terms of reaction-time, and learning in terms of decrease in errors and decrease in time. The experiments resulted in a decrease of reaction-time as the intensity of the punishment increased, and showed that time and errors decrease in proportion to the intensity of punishment. Results also suggest that the effect of the punishment is dependent on the subject's *insight into the task and the relation between the task and the punishment.* If the punishment did not *mean* 'wrong alley' it had no effect. It was, therefore, merely a way of *informing* the learner where not to go. The same results could have been as effectively produced if the experimenter had simply said "wrong alley." This experiment contains a hidden warning! Do not punish when insight can be appealed to.

Experiments on Rewards. On the side of rewards the facts of experiment are not as definite, although our educational system is based on rewards as well as punishments. Experiments on animals have demonstrated that the reward increases the tension under which the animal learns, if made more tempting or otherwise increased in value. This means that if a reward is, after all, to be a reward it must be the goal itself and not something external to it. Rewarding is increasing some property of the goal itself. Therefore, if rewards are to be included in order to motivate the learner toward a given goal *care*

[8] Hamilton, H. C., "The Effect of Incentives on Accuracy of Discrimination Measured on the Galton Bar." *Arch. Psy.*, 1929, Vol. 103, 73.

[9] Vaughn, J., and Diserens, C. M., "The Relative Effects of Various Intensities of Punishment on Learning and Efficiency." *J. Comp. Psy.*, 1930, Vol. 10, No. 1, 55-66.

must be taken that the reward and the goal are the same or the disastrous result occurs under the law of least action, of working for the reward and not for the goal. Kitson, as we have already pointed out, found great improvement in hand compositors when they worked under a special bonus system as a reward for progress. Their goal had been made more attractive. It was pay, and pay was increased.

Chapman and Feder on Rewards. Chapman and Feder [10] investigated the effect of external incentives on performances in simple addition, a cancellation test, and a substitution test where figures were substituted for numerals. Thirty-six boys and girls from grade 5A acted as subjects. They were divided into two equal groups. Group A was given the following external incentives: Each individual's results of the previous day were published; on the test sheets the score last made by the subject was marked in blue pencil; the general improvement of the class was presented in the form of a graph; credits were given in the form of stars to those who were in the upper fifty per cent on the previous day. It was understood that prizes would be given to the individual obtaining the greatest number of stars.

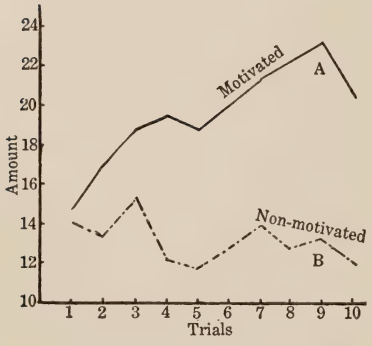

FIG. 37. CURVE SHOWING EFFECT OF EXTERNAL INCENTIVES ON ADDITION TEST (Chapman and Feder). By permission.

Group B, on the other hand, received no external incentives other than knowledge of the number of errors made in the addition test. The tests were given on ten successive days. The results of the addition test are shown in Fig. 37, and demonstrate that the non-motivated group made little if any improvement during the experiments, while the motivated group increased steadily in efficiency and general learning. The greatest difference between the motivated and the non-motivated groups appeared in the addi-

[10] Chapman, J. C., and Feder, R. B., "The Effect of External Incentives on Improvement." *J. Educ. Psy.*, 1917, Vol. 8, 469-474.

tion test. Next came the substitution test, and finally, the cancellation test where there was little, if any, difference between the two groups. It is significant that the cancellation test was finished by both groups in a shorter time than the others. The test was novel and novelty functioned as an incentive for both groups. This incentive, therefore, was not measured by the experiment. In the other tests which required a longer time, the novelty of the task disappeared and the other incentives showed their effect. The ordinary schoolroom task is of course of the longer type, which indicates that increased motivation of some kind would mean increased efficiency of achievement in the regular curriculum.

A Further Warning Regarding Rewards in School Situations. In spite of the results from experiments of this kind, a warning is necessary regarding the use of rewards in our educational system. Too often rewards earned are not true measures of the progress that the learner has made. In fact, they are most illusory. *Too often the individual who has acquired the greatest amount of usable knowledge is not rated the highest, or even toward the top of the scale.* Too often the quick learner, with a good memory for a short period of time, ranks high, but proceeds to forget what he has learned after the task has been performed and the reward has been earned. More deplorable still is the fact that a reward in school is not the goal itself, which is intellectual or motor *skill,* but it is *something else,* a grade, a star, social standing, praise. This *irrelevant* reward comes to represent the goal, something in itself to work for, which leads to learning *for the reward,* not for the sake of learning. The consequences of this situation have already been pointed out.

Mastering a task in an adequate and efficient fashion, for the sake of the knowledge and use that the mastery of the task is to give the individual, should be the true reward of the learning process. When motivation can be achieved by rewarding the learner with confidence, as shown in giving him a harder task to accomplish next time, the learning process is under the proper control. Our educational system falls short in these respects all the way from the first grade to the graduate schools of our universities.

Social Conditions of Learning

Social Stimulation: Allport's Experiment. Another method of motivating the individual is to introduce social stimulation through co-operative effort where each individual receives the advantages of contributions from his associates. Allport [11] tested the influence of the group on 'association' and thought, where the effects of rivalry were minimized. In the first four tests the subjects were given a paper with a word at the top and at a given signal wrote words as fast as they thought of them. The fifth test was on controlled association, in which the subjects wrote as many words as possible that referred to one particular subject, like 'winter.' The sixth test dealt with thought processes in which the learners presented an argument for or against some particular subject. The groups contained from three to five individuals. The results show that the presence of the group increases speed of free 'association'; that the slow individuals are more favorably affected than the rapid; that group influences are more potent in the early stages of the task than in later stages; and that more ideas of a personal character appear when the individual is alone.

Schmidt [12] compared quality of achievement in solitary home work with achievement in social, classroom work, in writing, composition and arithmetic. The latter proved superior; in fact, one group made 270 errors at home as against 184 at school. Omissions were characteristic of home work; superfluities appeared in the schoolroom.

Watson's Experiment on Social Motivation. Further differences between the individual working in the group and the individual working alone were pointed out by Watson.[13] He asked 108 graduate students to construct as many words as possible in ten minutes from a larger key word, without using the same letter twice in one word. The subjects worked twice individually and in groups of from three to ten. The

[11] Allport, F. H., "The Influence of the Group upon Association and Thought." *J. Exp. Psy.*, 1920, Vol. 3, 159-182.

[12] Schmidt, E., "Experimentelle Untersuchungen über die Hausaufgaben des Schulkindes. Sammlung von Abhandlungen zur psychologischen Pädagogie." 1904, No. 1, 181-300.

[13] Watson, G. B., "Do Groups Think more Efficiently than Individuals?" *J. Abn. and Soc. Psy.*, 1928, Vol. 23, 328-336.

group work was done orally, each group electing a secretary who recorded the words. Group thinking turned out to be distinctly superior to the average of individuals working alone and always exceeded the total of the best individuals. These studies would indicate that best results in achievement are ordinarily to be obtained when the learner is a member of a social group. The learner receives stimulation from watching the other members of the group at work, even if he does not know how well they are progressing.

Competition and Rivalry: Mayer. Competition is another form of social motivation. Mayer [14] compared the influence of work in isolation and in group situations in which competition was developed. School boys of an average age of fourteen were tested in written and mental arithmetic, writing from dictation, learning nonsense material, and completion of sentences. They were tested individually and in a group, and in one experiment, under instructions to work for speed and quality. Competition caused an improvement, over scores made in isolation, by 30 to 50 per cent.

Hurlock's Experiment. Hurlock [15] studied group rivalry in its relation to age, sex, and individual differences. 155 children of both sexes, ranging from nine to twelve years of age, took modified Courtis arithmetic tests. Stimulation in the form of discussion and publicity was given the rivalry group, but not to a control group of equal size. The control group was excelled by the rivalry group. Girls, younger children and those of inferior ability profited most by the rivalry motive. In this case rivalry increased the accuracy of performance.

Praise and Blame: Gilchrist and Hurlock. Social stimulation may also take the form of praise and blame, or encouragement and discouragement. The Courtis English test was given to a college class of fifty students by Gilchrist,[16] after which he divided the class into equal groups and repeated the

[14] Mayer, A., "Über Einzel- und Gesamtleistung des Schulkindes." *Arch. f.d. ges. Psy.*, 1903, Vol. 1, 276.

[15] Hurlock, E. B., "The Use of Group Rivalry as an Incentive." *J. Abn. and Soc. Psy.*, 1928, Vol. 22, 278-290.

[16] Gilchrist, E. P., "The Extent to Which Praise and Blame Affect a Pupil's Work." *Sch. and Soc.*, 1916, Vol. 4, 872-874.

test, praising one and reproving the other. The group that was reproved deteriorated in the second test, while the group that was praised made an improvement of 79 per cent.

The relative effects of praise and reproof applied continuously over a given period were studied by Hurlock.[17] Four groups of students worked in the same room on a test in addition. Two groups received praise and reproof while they worked. The two other groups, functioning as controls, heard the praise and the reproof but knew that it was not intended for them. The results show that regardless of age, sex, or initial ability, praise is the most effective of the incentives tested; reproof soon declines in effectiveness. The group that listened indifferently did the least work of all.

Summary of Conditions for Optimum Learning. A study of the conditions under which learning takes place has so far yielded the following facts of importance:

1. The whole method is superior to the so-called 'part method' of learning.

2. Under many conditions the mediating method is superior both to the unmodified whole method and to the 'part method.' Strictly speaking, the part method is an illusion. Behavior follows laws that do not permit learning by parts.

3. The longer the material the progressively longer the time required to learn it.

4. The longer the material the more efficient the methods employed in learning.

5. The longer the material the more necessary *logical form,* or *meaning,* becomes for adequate mastery.

6. The longer the material, other things being equal, the better it is retained, because of more efficient methods employed in learning. More efficient methods result in an increased grasp of logical form.

7. The rapid learner is the better retainer, because he learns by a more thorough use of the whole method.

8. Of the three general kinds of material studied, nonsense material, which has the least amount of form, is learned the slowest and the least efficiently.

[17] Hurlock, E. B., "The Value of Praise and Reproof as Incentives for Children." *Arch. Psy.,* 1924, No. 71, 78.

9. Meaningful material, possessing some form, is learned more rapidly and efficiently than meaningless material.

10. Material which has maximum logical form or pattern is learned the most rapidly and efficiently.

11. Failure of form to emerge when it is expected is detrimental to learning.

12. Knowledge of results leads to more rapid and efficient learning.

13. Recitation, introduced into the learning process, leads to more rapid and efficient learning than mere reading of the material.

14. With relatively meaningless or unfamiliar material a greater percentage of the total learning time should be spent in recitation than in the case of meaningful material.

15. Rewards and punishments, as methods of motivation, are effective in certain situations, but should be administered with care that the learner does not substitute the reward for the goal, and merely construct, as his goal, a performance that will not end in punishment.

16. In general, group stimulation, through co-operative effort, makes learning more effective, but may decrease efficiency in certain individuals.

17. Under limitations, the use of competition as a method of motivation increases the speed of learning and in some cases the quality of work. It may, however, decrease the quality.

18. Praise is more effective than blame in increasing the rate of learning.

19. The learner must have the attitude of learning in order to make progress. Awareness of a time limit generally increases the learner's output by stimulating the learning attitude.

20. Rewards and punishments are likely to destroy the attitude of learning by promoting social maladjustment and superficial methods employed only for temporary mastery.

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CHAPTER XVII

CONTROL OF THE LEARNING PROCESS—III

Temporal Relationships of Learning Material

Introduction. Conditions of learning such as kind of material, methods of motivation, and recitation, all cut across the factor of time relationships between periods of work. It will be necessary, therefore, to inspect this factor in view of ascertaining its influence upon the learning process. We have seen, in Guilford's experiment, when a series of numbers contained a pattern or form, that where a series having the same form was repeated, but with different items, it was learned more quickly than in the original trial. What is this relationship between a given task and a similar or different one repeated subsequently? If the learner masters algebra, what effect does this have on his subsequent learning of geometry? Do tasks that follow one another hinder or aid each other?

Before proceeding with the experimental evidence certain fundamental facts about behavior should be reiterated that will provide a background with which to understand the data. First, the learner never responds to an isolated stimulus; it is always a stimulus within a related field of stimuli. Thus, when a child studies one word in a sentence, he is in a measure studying the rest of the sentence at the same time, for he is studying the one word in its relation to the whole. Second, the individual-as-a-whole is responding to the stimulus-pattern. This means, for example, that the fingers of the right hand are not all that is involved in a process such as writing; *all* the rest of the organism is also involved. Third, each complete task is performed as a single act stretched out in time, nevertheless a temporal unit. This fact was evident when the dynamics of a falling body were examined. An act of learning is like a movement. It has a beginning, direction, and an end, all conditioned

at once by a complex set of factors. The end, therefore, is established before action starts. This explains the unity of the act in time.

Retroactive Inhibition: Webb's Study. A phenomenon of learning known as retroactive inhibition raises the question at once of the *time* relationships of two events in learning. Retroactive inhibition is an interference with the retention of given material by activities interpolated between the practice periods, or introduced immediately after the learning. It raises the following type of problem: Is it possible to study psychology after studying history without interfering with the retention of the history lesson? Webb [1] studied the effects of interpolated tasks on the retention of six types of simple mazes. He used both human beings and rats in the mazes, requiring them to learn first one maze, then another, after which he tested them for retention of the first. Retroactive inhibition was found in these motor performances. The learning of one maze, after another had already been learned, reduced retention of the original maze, for all but 37 per cent of his subjects in one experiment, and 26.7 per cent in another. A comparison of the human subjects with the rats showed that in three groups of the former 100 per cent of the individuals gave evidence of retroactive effects, while in no case was this true of all the rats. Webb also found that the easier the interpolated task, the greater the retroactive inhibition. Thus, if the task that was interpolated had been learned very quickly, there was a greater retroactive effect on the original task than if the interpolated task had been learned more slowly.

Robinson's Study of Retroactive Inhibition. Robinson [2] has made perhaps the most detailed of studies on retroactive inhibition. He investigated the problem where learning and interpolation were relatively dissimilar, where the two were relatively similar, and studied also the influence of the temporal position of interpolated work. There were five experiments in all. In the first experiment, the original materials were series of eight four-place numbers. Three minutes after presenting

[1] Webb, L. W., "Transfer of Training and Retroaction." *Psy. Mon.*, 1917, Vol. 24, No. 3.

[2] Robinson, E. S., "Some Factors Determining the Degree of Retroactive Inhibition." *Psy. Mon.*, 1920, Vol. 28, No. 128.

the number-series, the subjects were given one of the following tasks to perform for three minutes: (1) memorizing a second series of four-place numbers; (2) memorizing a series of twenty consonants arranged in a vertical column; (3) memorizing a passage of descriptive poetry; (4) solving four-place by four-place multiplication problems; (5) reading simple narrative prose with no attempt to memorize. At the end of this time the experimenter *asked* for a *recall* of the original material and then for a recall of the interpolated material. Each of the fifteen subjects went through each of the five conditions of the experiment three times. Results indicated that retroaction is greater when the original material and the interpolated task are highly similar, than when the interpolated task is dissimilar.

In experiment two the original material was the same as in experiment one, but the interpolated tasks were, (1) memorizing four-place numbers, (2) 32 digits in a series, (3) mental multiplication of two-place numbers by two-place numbers, (4) observing pictures attentively, (5) reading in current editions of the newspaper. As in the first experiment the greatest inhibition was produced by the memorization of the four-place numbers. Memorization of the 32 digits, as the interpolated task, caused more inhibition than observing pictures or engaging in mental multiplication. Among all the conditions, reading seemed to be the least effective. This experiment verified the conclusion that greatest retroactive inhibition takes place when the material is similar in content to the original, but also is greatest when similar *methods* of presenting the material are employed. That similar content alone will not condition inhibition was shown from the small effect of the multiplication problems in the two experiments.

Summary of Material on Retroaction. The relation between retroaction and the learning process is about as follows: First, retroactive inhibition is proportional to the difficulty of the material. Second, retroaction is greater when indifferent material is the interpolated task. Third, there is greater retroactive inhibition when the interpolated task is similar to the original not only in content but in the way in which it is presented. Fourth, there is less inhibition in individuals highly trained in the task. Fifth, the least inhibition occurs when the

interpolated activity is reading. Sixth, the degree of inhibition is independent of the temporal position of the interpolation. Seventh, there is no constant relation between degree of learning and retroaction. Eighth, progress in efficiency is more regular when reading is the interpolated task than when the task is similar to the original.

Interpretation of Retroaction. These results demonstrate that retroactive inhibition is not ascribable to the blocking of a setting process as earlier investigators proposed, since there is no relationship between inhibition and the temporal position of the interpolated task. Instead, the results point to an interpretation in terms of 'transfer of training.' The observer is still behaving with respect to the original goal when engaged in the interpolated task; he is still predisposed to recall the original material. This means that the learner has an unresolved tension when he begins the interpolated task. If the task is sufficiently *different* from the original one, then the tension is *not* resolved, and when recall is requested, the observer is able to make a better showing than when the interpolated material is similar. In the latter case, the tasks are so similar that the two kinds of activity are both perceived inadequately as members of the same configuration and thus are confused, with most of the tension resolved before the recall is requested. That this is true was borne out by the fact that if the content was similar, but presented in a sufficiently *different* fashion, less inhibition was present than when both content and presentation were similar to the original task.

Transfer Phenomena in Learning

Transfer of Training: Pyle's Experiment. In the foregoing discussion we have referred to 'transfer' as a factor basic to retroactive inhibition. By 'transfer' is generally meant a phenomenon of learning which is exactly the opposite of retroaction. In transfer, one task 'facilitates' the learning of another. The relation that we have just suggested between inhibition and facilitation must wait upon a discussion of the latter. In recent years the problem of transfer has received a great deal of attention from investigators, and many problems have been

raised. To what extent and under what conditions will the learning of one task *aid* in the learning of another, is a question of great importance for a study of the learning process.

Pyle [3] attacked the problem by employing card-sorting as a method. He used a set of boxes divided into 12 rows, the subjects learning a row a day by throwing numbered cards into compartments, labelled with a corresponding number. The question was whether the mastery of each succeeding row would be easier after the other rows had just been learned. His results were positive. Each succeeding row was learned with greater ease, although the sorting movements were different for each row. When the same experiment was repeated with 47 observers it was found that the fifth row of boxes was learned in 27 per cent less time than the first row. In another experiment the subjects worked with a set of thirty lettered boxes and then were given another set with the same number of boxes but with a different arrangement of letters. By the fifth day on the second problem, a speed was reached as great as that attained in fifteen days in the first experiment. (See Fig. 38.)

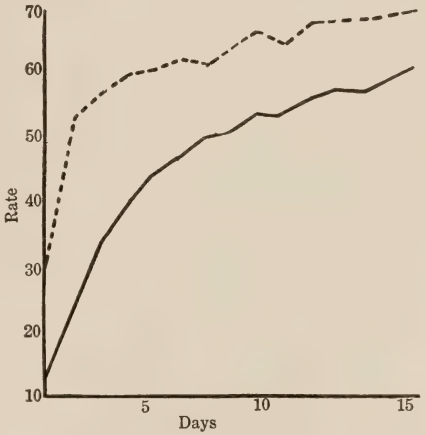

FIG. 38. CURVE SHOWING TRANSFER IN CARD SORTING (Pyle).

The dotted line shows the performance after 'transfer.' Note that the performance on the fifth day after transfer reached a speed equal to that of the 15th day in the original series. By permission.

Transfer and Memory: Sleight. Extensive experiments on memory transfer were performed by Sleight [4] who trained one group in memorizing poetry, another in memorizing tables and another in memorizing prose. The tasks to which they were transferred included memory of

[3] Pyle, W. H., *Psychology of Learning.* Baltimore: Warwick and York, 1928.

[4] Sleight, W. G., "Memory and Formal Discipline." *Brit. J. Psy.,* 1911, Vol. 4, 386.

dates, nonsense syllables, poetry, literal prose, the substance of prose, and letters. His general result from all of the tests, performed on both children and adults, was that training in one type of memorizing aided very little in other types of memorizing. There was some indication, however, that practice in learning poetry and tables 'aided' in learning dates, but not in learning prose substance. Practice in learning poetry 'aided' to some extent the learning of nonsense syllables, very little in learning tables, and, as compared with an unpracticed group, was a positive handicap in learning the substance of prose. Practice in learning prose substance did not aid in learning any of the other material.

Transfer of Theory. There are certain studies which show that there is a transfer of knowledge from an old, to the solution of a new, problem. Judd and Scholkow [5] tested subjects in shooting at a target under water. One group of subjects knew that the physical principle of refraction was involved and the other did not. The group that knew the principle were able more readily to adjust themselves to a change in the depth of the target under water than in the case of those that did not know the principle. Hyde and Leuba [6] tested subjects who had practiced reading German script with the task of learning to write German. These subjects were more efficient than unpracticed subjects.

Rugg's Experiment. Rugg [7] compared a group of 326 freshmen engineers who had a semester's training in descriptive geometry, with a control group of 87 untrained subjects. The control and the practice groups were given initial and final tests in non-geometrical material, quasi-geometrical material and geometrical material. Two tests in mental division, and constructing words out of the letters in M-A-T-E-R-I-A-L, were the non-geometrical tasks. Straight-line lettering constituted the quasi-geometrical task. There were two geometrical tests, one called the painted cube test and the other the procedure of

[5] Judd, C. H., and Scholkow, "The Relation of Special Training to General Intelligence." *Educ. Rev.*, 1908, Vol. 36, 28.

[6] Hyde, W., and Leuba, J. H., "Studies from the Bryn Mawr Psychological Laboratory. An Experiment in Learning to Make Hand Movements." *Psy. Rev.*, 1905, Vol. 12, 351-369.

[7] Rugg, H. O., *The Experimental Determination of Mental Discipline in School Studies.* Baltimore: Warwick and York, 1916.

imagining objects and determining how many lines would be required to construct them in space. In the painted cube test a solid three-inch cube was used, which was painted on all sides. The following questions were asked concerning it: How many one-inch cubes could you have that would be painted on three sides? On two sides? On one side? On no side?

Rugg found that in one of the mental division tests the practice group did .9 per cent less well than the control group. In the other division test the practice group made a gain of 15.78 per cent over the control. In the word-building test the practice group made a gain of 13.37 per cent over the control. It would of course be easier to excel on this test after having had descriptive geometry, because of the practice in visualizing that descriptive geometry affords. The improvement in straight-line lettering was 20.4 per cent more in the practice group than in the control, and the control group was surpassed by 31.25 per cent in the geometrical tests. It was conclusively demonstrated that 'transfer' took place from the work in descriptive geometry to the tasks that were at all related to geometry, and that the closer the relation, as in the case of the geometrical tests, the more the transfer.

Cross-Education: Ewert's Study. Recent studies on so-called transfer of training prove that, strictly speaking, *there is no transfer.* Indeed, the essential fact about that behavior designated as transfer *is a duplication of response in the first and subsequent performances.* This duplication can take place, (1) when there is a similarity of content, (2) where similar methods can be emphasized, and (3) where similar attitudes can be assumed. 'Transfer' can take place, then, only when the two tasks are so similar that the learner can apprehend them in the same whole, that is, perceive that the responses learned in the first task fit the second. The comprehensiveness of this perception determines the degree of the so-called transfer. The following experiments on 'cross-education' will illustrate the theory.

'Cross-education' is that type of 'transfer' observed when an activity learned with local movements of one part of the body is subsequently carried out by another part, as in case

of 'transferring' from right to left hand or from the hand to the foot.

Ewert [8] found evidence for 'cross-education' between the right and left hand. His subjects first learned to trace a star pattern with the right hand by the mirror drawing method. Then they shifted to the left hand and began immediately to trace the star with a performance that far exceeded the first trials with the right hand. The first tracing with the non-preferred hand showed an improvement of 36 per cent in the time required for the performance, over the original time required with the other hand, and a 21 per cent improvement in errors after fifty trials practice with the preferred hand. The transfer was also greater from the preferred hand to the non-preferred than in the opposite direction.

Bray's Experiment on 'Cross-Education.' Bray [9] performed experiments in 'cross-education' between the feet and the hands and *vice versa,* in addition to 'transfer' from hand to hand. His method combined in an ingenious way the mirror-writing technique and certain other motor skill methods. The subject was to hit a target seen indirectly in a mirror. In the hand experiment he held a pencil behind a screen placed between him and the target. Then he looked in the mirror and, at a given signal, struck at the target with his pencil. The method was essentially the same for the foot-experiment, except that the pencil was fastened to a light block of wood strapped to the subject's foot. In both cases the subject aimed at the target in time with a metronome. The first experiment involved transfer from hand to foot.

There were two groups of 14 subjects each. Group I was given 60 trials practice with the right hand, followed by 40 trials practice with the right foot. Group II received 40 trials with the right foot. After the transfer was made on the sixth day, the practice group (I) started with far fewer errors than the control group; the control group caught up with the former at about the tenth day. The initial error that the former group made upon being transferred was about equivalent to the error

[8] Ewert, P. H., "Bilateral Transfer in Mirror Drawing." *Ped. Sem.,* 1926, Vol. 33, 235-249.

[9] Bray, C. W., "Transfer of Learning." *J. Exp. Psy.,* 1928, Vol. 11, No. 6, 443-467.

made by the control group on their sixth day of practice. This meant that, after being transferred to the new task, there was a saving of about six days' practice. (*Cf.* Fig. 39.)

The effects of original training of various amounts previous to the 'transfer' was next investigated. This involved two more groups of subjects. Group III was given 20 trials with the right hand, and then practiced with the foot. Group IV had only 10 practice trials with the hand, followed by the transfer. The three curves obtained from the three periods of initial practice, 60, 20, and 10 trials, are very much alike. This indicates that practice after the *first few trials* with the hand is not carried over to the foot.

FIG. 39. CURVES SHOWING 'TRANSFER' FROM HAND TO FOOT (Bray).

The solid line is the curve of learning with the right foot for a group of subjects who had not had previous practice with the hand. The dashed line is the curve for a group of subjects who had had sixty trials with the right hand.

In order to study 'transfer' from the foot to the hand it was only necessary to give Group II, which already had 40 practice trials with the foot, 40 practice trials with the right hand. The records of this group were then compared with the initial hand records of Group I. The record of Group II, the transferred group, showed fewer errors at the outset and remained greater in accuracy throughout the experiment.

Lashley's Experiments on Transfer. We must now approach closer to the explanation of 'transfer' by means of experiments that suggest the dynamics of the process. If the subject learns a set of pictures with his left eye closed, will the picture seem strange when the right eye is blindfolded and the left eye open? Lashley [10] performed an experiment which gave

[10] Lashley, K. S., "Studies of Cerebral Function in Learning VI. The Theory that Synaptic Resistance is Reduced by the Passage of the Nerve Impulse." *Psy. Rev.*, 1924, Vol. 31, 369-376.

the answer. He blindfolded the left eye of a white rat, then trained it to avoid the brighter of two lights in a problem box. When the animal had not made an error for 30 consecutive trials he transferred the blindfold to the right eye. Perfect discrimination continued! Lashley explains that the nerve routes from the left eye proved at the outset to be equally as well integrated with the avoiding reaction as were the routes from the right eye after the latter had once been integrated.

Further experiments, this time on the Cebus monkey, were even more striking. Lashley paralyzed the left arm and hand of the animal by a brain operation, then trained it to open a latch box with the right hand. When the learning of these co-ordinations was complete, he paralyzed the animal's right hand and arm by another operation. After the right hand had recovered to some extent, he again tested the monkey. In the meantime, however, the animal had recovered the use of its left hand and was using it in other manipulations. When the latch box was again presented, the monkey at first fumbled clumsily at the catches with its right hand; then, *with no random movements, opened the fastenings successfully with its left hand. There was an almost perfect 'transfer' of the learned response to the hand that had been paralyzed during the original learning.*

Summary of Facts on 'Transfer.' The facts of 'transfer,' developed so far, may be summed up as follows: First, 'transfer' is greater when the task to which the subject is transposed is similar to the original in content and mode of presentation. Second, there is 'transfer,' in memorizing, from one task to another but similar one, as well as in making comparative judgments first with one kind of material and then with another. Third, knowledge of a general theory or principle is 'transferred' to tasks which are related to the theory. Fourth, there is 'transfer' from one hand to the other, with more from the preferred to the non-preferred than in the opposite direction. Fifth, 'transfer' also takes place from the hand to the foot and from the foot to the hand. Sixth, practice on a problem with one eye open is 'transferred' to the other eye when the first is closed. *Seventh, perfect 'transfer' from one hand to the other can take place when the unpracticed hand is paralyzed*

during the original learning. This latter fact will figure when, presently, the problem of explaining 'transfer' is raised.

Interpretation of Temporal Relations. In retroactive inhibition it was found that similarity of material and method of presentation were conducive to maximum effects. That this is true hinges to a large extent on the kind of material used, namely, nonsense syllables, tables, or lines of poetry. In this kind of material there is relatively little pattern; the pattern that exists is primarily a spatial one. With logical material interpolation has less, if any, effect, for logical form has more unity, individuality, and stability. When the observer faced an interpolated task, introduced before recall was requested, he had an unresolved tension toward recalling the material of the original task. If the task was similar, however, both tasks were members of the same configuration, not an organized, differentiated, configuration, but an undifferentiated pattern. This situation resulted in a confused recall of the original material. When, on the other hand, the two tasks were dissimilar they were not members of the same configuration, and recall of the original task was more accurate.

In the case of 'transfer of training' various studies show that 'transfer' is maximum when the tasks are similar in content and in method. It is curious that the conditions for maximum transfer and retroaction should be the same. It can mean but one thing: that the two sets of conditions measure the same process. In retroaction, however, the recall of the original task is deferred until after the interpolated task is completed; in transfer, the saving which the first task contributes to the second is measured when the second task is presented *without the first.* But there is one important difference between retroaction and 'transfer,' namely, the effect of the material used. In 'transfer' there is little aid derived from the memorization of a task that involves in the main only spatial relationships, like nonsense syllables, numbers and tables, or other material which has little or no pattern. Two tasks of this kind, if sufficiently similar, will be perceived as undifferentiated members of the same spatial and temporal pattern, but there is so little general plan or order running through this kind of material that the fact they are members of the same general configuration is no advantage

as far as 'transfer' from the one task to the other is concerned. On the other hand, *lack* of form or pattern is conducive to retroactive inhibition.

A Theory of 'Transfer.' The fact of 'transfer' has rather wide implications for an interpretation of the learning process. The learner is responding, as a unified organism, to a total stimulus-pattern. His behavior falls under the law of configuration, as illustrated by the fact that when he practiced with one hand in the 'cross-education' problems, the other hand and the foot 'improved.' This means that the activity of the one hand in the first place was derived and determined by *the total neuromuscular system.* (Laws of derived properties and determined action.) The entire system determined how the original hand was to function. In like manner *this same system, at the same time,* determined how the other hand and the foot were to function. *The entire system was learning to write, or to aim in the mirror.* The local hand movements made at the outset were differentiations from mass action. The fact that this differentiation comes from the entire system means that movements of other parts of the body are potentially differentiating also, for the parts of the whole emerge together. (Laws of individuation and field genesis.) When, therefore, the 'transfer' occurs it is only a system, 'trained' as a whole, conditioning the activities of its parts. Actually there is no 'transfer' at all, except from one *situation* to another. There is no transfer within the organism except that now a hand is the organ most used, now a foot or the other hand.

The so-called transfer is not one hundred per cent because the two situations are not entirely the same. In case of the hand the relation of the fingers and thumb with respect to the body is different. The grasp and the movements cannot, therefore, be the same. This means, in turn, that there are *new problems* of co-ordination to be solved only by meeting the new situation. *Insofar as the whole-part relations are the same there is perfect transfer, as in case of the experiment with the two eyes, and also where the learner is sufficiently mature to perceive in advance the differences between the old and new situations.* 'Transfer,' then, is a matter of insight into total sit-

uations, as was illustrated by Lashley's monkey. It is a phenomenon akin to reasoning and prediction.

'Transfer' from one kind of subject matter to another is no different, in principle, from 'cross-education.' That there is 'transfer' where there is similarity of content or method merely means, again, that a *total pattern* of response is conditioning the activity of its parts. 'Cross-education' involves a maximum of similar content and method.

If one attempts to explain 'transfer' on the basis of 'common elements' he is doomed to failure, because there are no elements common or uncommon. The total system conditions the 'transfer.' Suppose, however, we grant the existence of common elements. What would they, of necessity, be? They would be *particular movements* made in common by the trained part and the untrained part. These are *separate movements* made by different parts of the body. How could either one of these separate parts be aware of what the other was doing? We are thrown back, therefore, upon the necessity of considering the 'common elements,' even if granted, as the emerged local movements *which are end products, not causes* of 'transfer.'

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CHAPTER XVIII

CONTROL OF THE LEARNING PROCESS—IV

The Problem of Incidental Learning

Incidental Learning: Myers' Experiment. There is another problem which bears upon the question of temporal relationships in the learning process, namely, *incidental learning.* The question arises, Will the learner profit, in a subsequent recall, by carrying out, meanwhile, a given activity with no instructions to memorize or to learn? This problem naturally follows from the previous discussion of 'transfer.'

Myers [1] undertook research on this problem in which he requested subjects of different ages to judge the characteristics of familiar objects (dollar bill, coins). He found that the sizes and proportions of these objects are, almost universally, overestimated or underestimated. The error, however, seemed to decrease with increasing age of the judges. In everyday life one is not required to make accurate judgments concerning the size and proportions of commonplace things. As a consequence, when called upon to make precise statements about their properties, judgments are very inaccurate. Incidental memory, then, is proverbially unreliable.

In another experiment, Myers had his subjects read words under conditions seemingly foreign to the purpose of the experiment. Then he asked for a subsequent recall. There was little difference in efficiency between children and college students as far as immediate recall was concerned, but when a delayed recall was required of both groups the college students showed a marked superiority. Evidently, the college group had profited by a factor that was not operating in case of the young children. This factor could have been nothing else but the

[1] Myers, G. C., "A Study of Incidental Memory." *Arch. Psy.,* 1913, Vol. 4, 108.

effect of having made, in general, more observations about the objects and situations represented by the words. That is to say, the college group perceived the words in a larger *whole* of incidental fact than did the children.

Kirkpatrick on Incidental Learning. The rôle played by the *presence or absence* of incidental observations was investigated by Kirkpatrick.[2] Working with children, he attempted to ascertain whether the multiplication table could be learned better through practice, incidentally, or by deliberate memorization, followed by practice. The material included the numbers from 17 to 53 multiplied by 7. One group memorized the numbers for five or six days with full realization that they were arriving at mathematical products. Then they began writing the tables. The other group began writing the operations without specific knowledge of their meaning. The memorizers showed improvement on the second day, but fell behind the other group by the tenth day. A two weeks' interval was then introduced, when, after a short review, both groups wrote as many products as they could in two minutes without aid from any source. The memory group averaged 40.9 correct responses and the writing group 46.2.

In another experiment the relative merits of merely practicing the numbers were compared with the method of actually computing the products. The subjects were adults. The writing group averaged 25.4 on the final test and the computers 44.3. Additional experiments, this time on children, confirmed the superiority of computing to practice writing, and also showed a superiority on the part of children who had both practiced and memorized over those who had only memorized. These experiments demonstrate that the products of multiplied numbers are learned best either through processes of incidental learning, attending actual use of the products, or by processes of computing the answers. Either procedure gives the numbers meaning which they could not acquire through memorization. *Memorization, as such, is ineffective.*

Kirkpatrick points out that a similar situation obtains in connection with the alphabet. The alphabet can be taught as

[2] Kirkpatrick, E. A., "An Experiment on Memorizing *versus* Incidental Learning." *J. Educ. Psy.*, 1914, Vol. 5, 405-412.

effectively *while learning to read* as it was formerly taught by a prolonged period of drill. He would conclude that it is better to learn number products incidentally and by computing them, rather than by drill.

Willoughby's Experiment. More recently, Willoughby [3] has added to our knowledge of incidental learning. He used in all 300 subjects, including a basic group of children 13 years old, their fathers and mothers, brothers and sisters and other available relatives, as well as many adults who were not related to the children. With no instructions to memorize, the subjects were first asked to substitute symbols for pages of figures, with the aid of a key at the top of the page. The time allowed for the test was two minutes and thirty seconds. At the end of this time each subject wrote from memory the numbers with the proper symbols as given in the key. In this test, the first four symbols were practiced eleven times each, the next five, ten times, and the last four, nine times. The first numbers were practiced more at the beginning of the test and the last more at the end of the test. It might, therefore, be expected that subjects making a poor score on the substitution test (not completing the test) would also make a poor score in recall, because they had not had an opportunity to learn the numbers at the end of the test. Willoughby found that there was a low but significant relationship between score on recall and the amount of practice in the original substitution. The maximum scores in both the substitution and the recall were obtained by subjects about 21 years of age. The principal condition of good recall was youthfulness (ages 10-25). Neither ability to substitute, nor school grades, were conditions of good recall. Here again the facts prove the existence of incidental learning. The subjects were not required by the instructions to memorize any of the symbols, yet, when asked to recall them later, they remembered many of them. Moreover, there was no relation between the amount recalled and the length of time spent in the original experiment.

A Theory of Incidental Learning. In incidental learning, the learner is responding to a total stimulus-pattern, not to

[3] Willoughby, R. R., "Incidental Learning." *J. Educ. Psy.*, 1929, Vol. 20, 671-682. 1930, Vol. 21, 12-23.

isolated stimuli. An object is perceived at the time in relation to others; it is a member of a relatively extensive field of experience. (Law of configuration.) Although the learner *did not, by instruction, respond to a wide field of stimuli at the time, he could not react to a particular stimulus without, at the same time, and in some measure, responding to the rest of the field.* So, when he was writing numbers, without intending to remember them, he was responding to numbers by apprehending them in their relationships. For example, in copying $17 \times 7 = 119$, $18 \times 7 = 126$, $19 \times 7 = 133$, the plan of a total mathematical situation was being observed, such as: 'Where two 7's occur together there is a 9,' or, 'Where a 9 and 7 occur together there is a 3.' Mathematical systems were evolving which aided in subsequent recall, according to the law of determined action. *Learning that takes place incidentally, then, is the unobserved part of an organized response to a total stimulus-field.*

Incidental Learning and the Will to Learn. The facts of incidental learning are not inconsistent with the principle that there is no learning where there is no will to learn. First, the incidental learning is subordinate to the goal of the learner at the time, or the observations would not have been made. Second, incidental learning follows the same law as the law of will, namely *determined action.* Observing and willing are only descriptively different; they are not different in principle when they operate in accordance with the same laws. Moreover, incidental learning must follow the law of configuration; so must the will, because an isolated 'will act' cannot be made in response to an isolated stimulus.

Periodic Character of Behavior

Periodicity and Rhythm in Learning: Wheeler. In recent years much time has been devoted to the periodic nature of work, continued in time. Breathing, eating, heart action, sleeping, everything we do in fact, is rhythmic in character, under undisturbed conditions. Individuals also have characteristic rhythms in their intellectual work; some work most efficiently in the morning, others late at night. In either case there is a

high peak of activity at one time of the day and a corresponding low point at another time, in addition to certain periodic fluctuations which may be several days, a week, or longer, in duration. Similarly, records of muscular contraction, taken with the index finger as it continuously lifts a weight, show

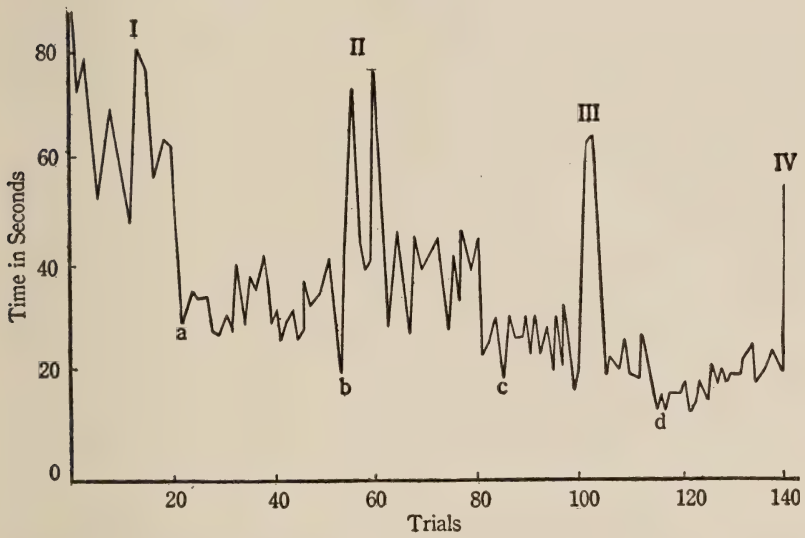

FIG. 40. CURVE OF BLINDFOLD MAZE TRACING SHOWING PERIODICITY.

This is a curve of a single subject, obtained in the Kansas Laboratory, who made 140 consecutive tracings of the maze. Steeples (I to IV) appear at regular intervals of approximately forty circuits. Low points in the curve marking the limits of fairly well defined waves occur at 30-circuit intervals. Curves of different subjects show a wide variety of waves, some contours of which are more, some less, distinct, but all curves reveal a periodicity.

clear-cut rhythms in the amplitude of contractions. Factory workers, or other individuals who make stereotyped movements for hours at a time, show a periodic fluctuation in their output.

In a study of blindfold maze tracing, Wheeler [4] found most striking periodicity, under continuous practice of two hours or more in length. The maze had no blind alleys, but the sides of the alleys were notched so that unless the subject kept his stylus in the center of the alley the notches impeded his progress. The maze was traced continuously without opportunity to re-

[4] Wheeler, R. H., *Science of Psychology.* New York: Crowell, 1929, p. 306.

lax. Time records in seconds were taken for each tracing. Fig. 40 shows a typical record in which the waves in the learning curve appear at approximately equal intervals, with a characteristic pattern running throughout. The periodic nature of the curve, and the characteristic pattern, were features of the records obtained from all observers. In many instances the low points of the curve at the beginning and end of a wave, or period, can be predicted in advance with surprising mathematical certainty, when the contour of the first part of the curve is used as a basis.

There is also evidence that the subject's attitudes, determination, and willingness, fluctuate with the rhythms of the curve. That muscular co-ordinations and the observers' 'mental processes' should fluctuate at the same rate and at the same time indicates the general character of the rhythm. It is something that involves the entire organism; the changes in attitudes and motor co-ordination are merely 'parts' whose properties are conditioned by the organism-as-a-whole. Rhythm, then, is a *field property* which determines what the rhythms of the parts will be. Further evidence that this is true is found in the fact that when the periodic changes are being observed, a stimulus which supposedly disturbs the organism in one part will alter the periodic fluctuations in other parts of the organism as well. For example, while the observer is continuously contracting his index finger he hears a loud sound. The rhythm of his contractions is affected, and also of his breathing, heart action, and contractions of the alimentary tract. It is becoming evident that all of the body-functions, including voluntary behavior and the vegetative activities of the body, are one vast periodic performance within which are numerous and subordinate periodicities interrelated in an orderly fashion like the partials of a complex tone. This true, what we have said must follow, because every rhythm is dynamically adjusted to every other and a disturbance of one disturbs them all.

Sarvis' Study of Periodicity. Sarvis [5] has made an elaborate investigation of this periodicity in prolonged motor activity. Not only did he find numerous rhythms within

[5] Sarvis, B. C., *Periodicity in Prolonged Motor Activity.* 1931, University of Kansas. Dissertation.

rhythms but that, during prolonged motor activity, carried out several hours a day for many weeks, the minor rhythms gradually disappeared and the patterns of the major rhythms, often quite irregular at first, became more even and symmetrical. In addition, their amplitude progressively decreased. The total picture is that of a motor pattern becoming more and more stable, under the law of least action. Sarvis also investigated the difference between motor rhythms where the task was relatively easy and involved only gross, mass action, and where the task was intricate and difficult. In the former case the rhythms were less complex and became stabilized more rapidly. Finally, he found that the learner, provided he co-operated in the experiment, could not interfere in any material way with the course of a given rhythm. When he was temporarily losing his co-ordinations no amount of effort would appreciably affect his performance. When he was gaining in co-ordination *extra* effort was of no avail. This study has an important bearing upon the learning of any task where maturation is slow. The learner's natural rhythms of improvement should be watched and his work periods timed accordingly.

Value of Rhythm. Obviously rhythm is an important condition for the preservation of body energy. The heart, for example, rests momentarily between beats. The muscles of the chest relax for a brief instant between expiration and inspiration. It seems probable that the periodicity in voluntary activities possesses the same function, namely, that of providing the behaving organism opportunity for recovery from periods of intense work. This does not explain the rhythm; it merely assigns it a value. There are other ways of looking at periodicity, especially in the learning process. High and low periods are 'work' and 'rest' periods. Think of the 'rest' periods as intervals between practice periods, and recall the frequent observation that, after a 'rest' period, the learner returns to a given task more efficient than at any previous trial. This important fact of learning, next to be discussed, evidently grows out of the intrinsically rhythmic character of all body functions.

Distribution of Work and Rest Periods

Spacing of Work and Rest Periods: Lyon. There is no more vital problem in learning than the proper spacing of work and rest periods. This is because (1) learning is a product of maturation, and maturation takes time; (2) learning is work and the body requires time to recover from work. Many questions arise in connection with the problem of spacing. For example, should the learner be given a certain task all in one sitting or should he be given a few repetitions of the material, then a rest period, then another period of work? Lyon [6] has made a study of this problem, where he varied the kind of material, but held constant the same distribution of work and rest periods. Also, he investigated the relation of the length of study periods to their most effective temporal distribution. His observers memorized varying amounts of nonsense syllables, digits, prose and poetry in one sitting and at the rate of one repetition a day. In the case both of nonsense syllables and of digits, the shorter lists were more readily learned when efforts were distributed, and, as the units were increased in length, the spacing of practice introduced all the more economy. There appeared to be no consistent saving in time by distributing the memorizing of logical materials, prose and poetry.

Miss Perkins' Experiment. An experiment was performed by Perkins [7] which permits of comparison between the relative influence of the length of the study periods and the intervals lapsing between them. Sixteen repetitions of nonsense lists were divided into periods of 1, 2, 4, and 8 readings, and 1-, 2-, 3-, and 4-day intervals for each period-length. This meant that there were sixteen different distributions of the material. She selected as her criterion of learning the percentage of syllables correctly recalled after a two-week interval. The following table summarizes her results:

[6] Lyon, D. O., "The Relation of Length of Material to Time Taken for Learning and the Optimum Distribution of Time." *J. Educ. Psy.*, 1914, Vol. 5, 1-9, 85-91, 155-163.

[7] Perkins, N. L., "The Value of Distributed Repetitions in Rote Learning." *Brit. J. Psy.*, 1914, Vol. 7, 253-261.

TABLE VIII

RELATION OF RECESS PERIODS TO LEARNING

	Day Interval			
	1	2	3	4
	Per cent	Per cent	Per cent	Per cent
1 reading	79	72	82	68
2 readings	43	78	65	45
4 readings	25	33	29	41
8 readings	9	16	11	17

These data show that with one reading of the list each day until sixteen readings had been made, there was a recall after the two-week period of 79 per cent of the syllables. When there were two readings of the list for eight days the retention was only 43 per cent. Four readings a day for four days ended in a retention of 25 per cent, and when eight readings a day were made for two days only 9 per cent of the syllables were remembered. Thus, when total time devoted to the learning was held relatively constant, the shorter work periods, more widely distributed, were universally the most advantageous. Within the limits of the experiment, varying the length of the practice period had more influence on the amount recalled than varying intervals between practices. The main result was that the percentage of syllables recalled was inversely proportional to the length of the study period.

Distribution of Practice in Motor Learning: Pyle and Lashley. Pyle [8] investigated the relative practicability of two different distributions of work periods. One group of five subjects practiced typewriting ten half-hour periods each day during the course of the experiment, with a half-hour rest between each period. The other group practiced only two half-hour periods each day. Strangely enough, this group maintained a 25 per cent superiority in speed over the other throughout the experiment, and a 12 per cent to 223 per cent superiority in accuracy. Notice that the poorer group had by far the greater amount of practice, showing that repetition did not account for the learning.

[8] Pyle, W. H., "Concentrated *versus* Distributed Practice." *J. Educ. Psy.*, 1915, Vol. 5, 247-258.

Lashley,[9] also in an experiment on motor learning, gave archery practice to his subjects at the rate of 5, 12, 20, 40, and 60 shots per day for 360 shots at the target. Obviously, for those who shot only 5 times a day, distribution of practice was the widest in proportion to total number of shots. There was little or no relation between the extent of distribution and the improvement in accuracy of shooting, during the first 180 shots, but during the last half of the practice those who made fewer shots a day were the more accurate.

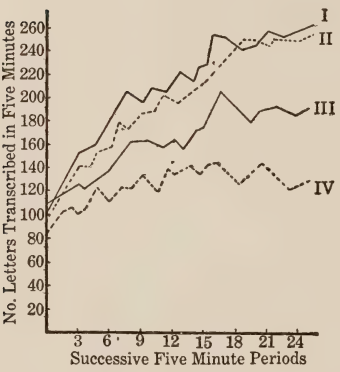

FIG. 41. CURVES SHOWING THE VALUE OF SPACED REPETITIONS (Starch).

Curve I shows the performance of the 10-minute group; curve II shows the performance of the 20-minute group; III is the performance of a group that worked for two one-hour periods, and IV is the showing made by the group that worked steadily for two successive hours. All groups spent the same amount of time at the task.

Distribution of Work Periods in Code Translation: Starch. Starch[10] performed a classical experiment in which he introduced various distributions of 120 minutes' practice time. His subjects substituted numbers for letters according to a key. For different groups the total practice time was divided into periods of 10, 20, 40, and 120 minutes, with different time intervals between work periods of different length. He selected the amount of work done in any five-minute period as a convenient unit with which to measure progress in the learning. Fig. 41 shows these successive five-minute periods plotted against the number of letters transcribed during that time. The group of subjects that worked 10 minutes twice a day for six days made by far the most rapid progress and the greatest total gain. The group working for a 20-minute period each day for six days

[9] Lashley, K. S., "The Acquisition of Skill in Archery." *Papers from the Department of Marine Biology of the Carnegie Institution of Washington,* 1915, Vol. 7, 105-128.

[10] Starch, D., "Periods of Work in Learning." *J. Educ. Psy.,* 1912, Vol. 3, 209-213.

did less well; the group working for 120 minutes continuously made the poorest record.

Distribution in Case of Logical Material: Austin and Gordon. Austin [11] compared one reading of *logical material* a day for 5 successive days, with 5 continuous readings of the same material in one sitting. He found that for immediate recall bunched effort was 1.6 per cent superior to distributed effort, but for recall after two weeks the distributed effort was 24.13 per cent superior, and for recall after one month 19.1 per cent superior. The two distributions had about equal value for immediate recall, but the distributed work yielded about three times the results obtained by continuous study, when recall was requested after a delay of two weeks or a month. The same investigation was extended to 32 college students who studied a textbook assignment in three continuous readings, and to 53 students who read the assignment once a day for three days. The results show no significant advantage in distributed effort when immediate recall was the goal in learning, but when delayed recall was requested, distributing the work periods proved to be the superior method.

Gordon [12] carried on some class experiments in which the learning of a meaningful passage was tested by the ability of 101 college students to recall it word for word. For immediate recall, six readings of the passage at one time proved equal to two periods of three readings each separated by a three-day interval. Continuous reading, however, again proved its inferiority for recall after one month. Three readings, with week intervals, proved less economical for immediate recall than the same length of time spent continuously. On the other hand, the distributed study led to more economical recall three weeks later.

The Irradiation Pattern: Snoddy. It has become evident, from a study of distributed work and rest periods, that distributed practice results in more efficient learning than continuous practice. Snoddy's [13] study of mirror tracing, already

[11] Austin, S. D. M., "A Study in Logical Memory." *Amer. J. Psy.*, 1921, Vol. 32, 370-403.

[12] Gordon, K., "Class Results with Spaced and Unspaced Memorizing." *J. Exp. Psy.*, 1925, Vol. 8, 337-343.

[13] Snoddy, G. S., *op. cit.*

cited, brought to light reasons why bunched or *series-practice* is less advantageous than distributed or *recess-practice.* He used a star pattern which his subjects traced in mirror vision. The mirror caused a reversal of the direction in which the subjects were obliged to move in following the pattern. In order to progress they moved their stylus in the opposite direction from that which at first appeared to be correct. Spaced work periods were found to be essential to improvement in the earlier part of the learning, and it was not until the new movements had emerged, well co-ordinated, and with the attainment of considerable speed, that series-practice could be employed successfully.

Reports from his observers showed that, under conditions of continuous practice early in the learning, there was a marked change of attitude from caution and accuracy to carelessness and speed. Snoddy regarded this change as inevitable because, as the repetitions accumulated, the subjects brought into play more and more arm musculature; consequently, they became tense and lost their co-ordination. This spreading effect and loss of co-ordination was called by Snoddy an *irradiation pattern.* That this pattern involved the whole nervous system could be demonstrated by the fact that not only was there a general spreading of muscular tenseness, but *also a change in the observer's manner of perceiving the star.* When recess-practice was introduced, with the opportunity for rest periods, and a slow deliberate procedure, the subject confined his gaze, during the first stages of the learning process, to a region near the end of the stylus. Then, as time went on, improved co-ordination emerged, together with a gradual enlargement of the area which the subject comprehended in a single glance. With bunched or continuous practice, however, this was not true; the scope of a single glance increased very rapidly and the viewing was superficial. In fact, the learner was unable to judge the corners and sides of the star with any degree of accuracy. This of course meant that the tracing of the star pattern would be inaccurate. With the distributed practice the reverse was true; the judgments increased in accuracy as they increased in complexity.

Value of the Rest Period. An irradiation pattern eventually sets in whenever work periods are sufficiently prolonged. The individual who has written a long letter in script, even with

the firm intent to keep it legible throughout, finds, in reading it over, that the first page looks pretty well, the third is not quite so good, the sixth is somewhat of a scrawl and the eighth is hardly readable. While he was writing he was becoming more and more tense, and by the time the end of the letter was reached he was suffering from writer's cramp. Essentially the same thing occurs in prolonged periods of studying a difficult task. The student works continuously on a problem in physics and is less efficient at the end than he was toward the beginning. His 'mind turns a blank'; this 'blankness' corresponds to the muscular tenseness produced by repetition of the same movements over and over again without rest. It is a symptom of irradiation. The individual lacks the energy to maintain the complicated and differentiated pattern necessary for progress in the problem. In order to proceed he must have more energy than is now available. He must rest. But his condition is not fatigue altogether. It is also *over-stimulation* which has dissipated the energy that, for adequate motor co-ordination and adequate thinking, must be aligned into differentials of potential of a very delicate and precise nature. The dissipation has rendered this energy unavailable for work, but it need not have exhausted it. A recess period is necessary to permit readjustment of this energy in the nervous system.

The Rest Period and Maturation. Meanwhile, there have been other factors at work, most prominent among them the *growth* potential, that has been raised by stimulation. This growth potential, as we have seen, is resolved in processes of maturation, and maturation takes time. The recess period is important, therefore, for at least three reasons: (1) to permit a replenishing of the lowered energy supply; (2) to overcome the effects of over-stimulation, which are faulty energy distributions, and (3) to permit maturation with its increased differentiation of energy patterns.

The rest period over, the learner approaches his task with more energy and a more highly differentiated system. This permits him to perceive the goal and the path to the goal in a greater detail of relationships than at any previous time. The fact that he perceives more relationships means that he can now make further progress in the task. If the student, attempting

late at night to solve his physics problem by continuous practice, introduces the necessary rest period by going to bed, then attacks the physics problem in the morning, the solution is easy. This is not because the student has solved the problem in his sleep, but because he has matured sufficiently with respect to the task. He has acquired an increase in available energy which enables him, now, to perceive the detailed relationships necessary for a solution.

Irradiation in School. Although spaced work periods are a necessary condition of learning we almost constantly proceed as if the opposite were true. In the teaching of school subjects, mathematics, spelling, and so on, are presented over and over again in the form of continuous practice or drill, day after day, as the means of promoting the learning process over the months. Drill, instead of guaranteeing efficient learning, sterilizes the insight of the learner and kills his interest in the task by the creation of irradiation patterns on a large scale. In fact, nervous break-downs are examples of irradiation, induced by excessive, continuous work and prolonged emotional stress.

A Striking Case of Irradiation in Industry. In certain supposedly well-learned activities, carried on in a continuous fashion, without evident loss in efficiency, there is evidence that maximum output is restricted by irradiation patterns, induced by prolonged work. Frequently the worker can be made to improve remarkably by distributing his efforts. Jones [14] reports a case of this sort in an industrial plant. He took a group of employees whose normal rate of output, with continuous work, was 16 pieces an hour. With a 25-minute work period and a rest period of 5 minutes, the rate was increased to 18 pieces per hour; with a 17-minute period, with 3-minute rest, 22 pieces per hour were produced; and with a 10-minute work period and 2-minute rest period, there were produced 25 pieces per hour. In another case, continuous work at driving rivets was divided into one-and-three-quarter-minute periods separated by two minutes' rest. The result was extraordinary. There was an increase in the total amount from 600 rivets a day, under the old conditions of continuous practice, to 1600

[14] Jones, E. D., *Administration of Industrial Enterprises.* New York: Longmans, Green, 1919.

per day, with distributed work and rest periods. *That resting 5 hours and 20 minutes out of a 10-hour work day increased the output 266 per cent* well illustrates the importance of distributed work and rest periods in industrial situations. This study proves that even a task apparently learned, but executed under conditions of continuous work, is subject to marked improvement under conditions of distributed work. In the example just cited there was an irradiation pattern of long and, under the conditions, permanent duration, that was easily eliminated.

The Plateau: Bryan and Harter. A pioneer study on learning the telegraphic language was made by Bryan and Harter,[15] who raised some interesting questions about the nature of progress in learning. They plotted the number of letters, decoded per minute, against weeks' practice. In one subject, progress continued at a fairly uniform rate for the first sixteen weeks, with equal amounts of practice each day. In the eight weeks that followed, progress ceased almost entirely, only to begin again at the end of that time. Another showed two periods during which there was no visible progress. (See Fig. 42.) These stationary periods or *plateaus* which seemed to appear in all kinds of learning problems, attracted a great deal of attention and resulted in a prolonged controversy as to their cause.

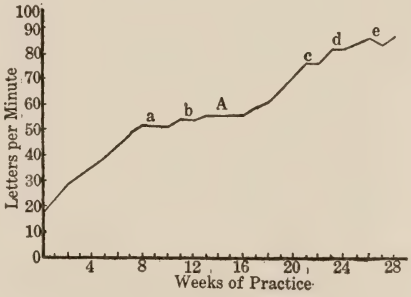

FIG. 42. CURVE SHOWING TYPICAL PLATEAUS (Bryan and Harter).

A marks a major plateau; a, b, c, d, e, minor plateaus.

Older Theories of the Plateau. The plateau was regarded by the earlier investigators as something inherent in the learning process, but their theories were widely conflicting. One group believed that the learning process consisted of acquiring a hierarchy of habits. Learning to receive the Morse code, for example, was explained in this way by Bryan and Harter. The first habit that must be perfected was supposedly

[15] Bryan and Harter, *op. cit.*

that of perceiving letters, a second habit must then be formed in which the sound of the letters are re-perceived as sounds in organized patterns representing whole words, instead of individual dots and dashes. After this habit had been perfected another procedure was required in order to combine the words into phrases; and perhaps yet another in order to combine phrases into sentences. Bryan and Harter believed that a plateau appeared while the learner was assimilating a simple order of habits sufficiently to permit their organization into a higher order. Aside from the logical fallacy inherent in a theory of this kind, further experimentation failed to substantiate it.

A second group of investigators held that the plateau was caused by a decline of interest in the task. Evidence showed, however, that when the learner is concentrating his best on the problem, plateaus may appear. He is attempting to make further progress, and is interested in his improvement, but enters upon a period of no progress, notwithstanding. It is true that interest often declines during the course of a plateau, but this will not account for its *formation.* A third theory postulated that, after the learner had made too rapid a progress, he was obliged to moderate his speed in order to assimilate the material already covered. This theory was invalidated by the general lack of correlation between amount learned and the position of the plateau. Against all of these theories is the fact that the plateau appears anywhere in the course of the learning, and further, that a plateau does not always appear in different individuals in the same type of performance or in every individual who learns a given task. These facts indicate a dependence of the plateau on conditions, external to the learning process, that may be brought under control.

The Plateau in Relation to Irradiation. That the plateau is another way of describing an irradiation pattern is at once obvious. This period of no progress is characterized by an inability to form an adequate configuration of the necessary mental processes and muscular movements. As we have seen, the formation of an irradiation pattern is conditioned by too continuous a stimulation. Proof of this was presented by Snoddy when he controlled the formation of plateaus in maze learning by the proper distribution of work and rest periods.

The appearance of the plateau means faulty distribution of stimulation. The monotony and the lack of interest, formerly regarded as causes of plateaus, prove only to be symptoms of irradiation. These facts mean that the problem, in any kind of learning activity, is to discover the proper kind of series-practice in order that the learner may make steady progress from the first presentation of the problem to the goal of mastery. When this procedure is followed the vitiating effects of drill, with its consequent lack of progress, will be eliminated. *If economy in learning is the ultimate goal of a study of the learning process, one of the first steps should be to eliminate the lost motion of fruitless practice.*

Pacing: A Major Problem in Learning. We have seen that over-stimulation is detrimental to efficient learning and, on the other hand, that the learner will not maturate if not adequately stimulated. Between these two extremes lies moderate stimulation, which, when properly controlled, leads to steady normal development during the course of learning. The procedure of distributing work periods of proper length and difficulty for steady and efficient progress is applying the principle of *pacing.* It consists, specifically, of giving the learner more and more complex tasks to perform, in accordance with his rate of maturation. What the rate of pacing should be is easily ascertained by observing the learner. The task fits the learner's level of maturation if he can master it perfectly the first time. If he cannot, the task is too difficult and should not have been presented. The difficulty of the problem should at no time be beyond the child's stage of maturation. If this simple rule were followed the learner would not waste time in drill or practice without making progress; he would not enter upon a plateau induced by the formation of an irradiation pattern. As soon as he has mastered a task of a given difficulty he should be allowed to rest, if he is not eager to proceed, in order to permit maturation. That the learner has been allowed to mature means that the next problem presented him can be more complex, yet mastered at once. A conscientious learner *cannot remain interested unless he is mastering new and more difficult tasks continuously,* a fact demonstrable all the way from the kindergarten to the university.

Wastefulness of Errors in Learning. It is a common observation that when the individual finally solves a problem which he has confronted many times, *the solution emerges suddenly,* not as a gradual elimination of errors and a retaining of correct responses. *Any error that he previously made represented his solution of a problem as he perceived it, at his level of maturation.* If he had been allowed, without the so-called erroneous solutions, to mature to the level ultimately required of him at the time by whoever imposed the task, he could have solved the problem the first time without the errors. *Errors are NEVER necessary for solutions; they are an indication that learning is under inadequate control.*

In Patton's experiment, previously described, in which two pairs of greys were presented at one time, then two more and so on, through a series, the observer's problem was to discover a plan or theory that would enable him to make all correct choices. *It was found that at every stage in the process of learning, the learner had a theory which was conditioned by his perception of the problem, in accordance with his level of maturation.* The final solution, the one called correct, came suddenly in an organized fashion, and was new. If the learner had been given a series of problems of increasing complexity, each just complex enough so that he could solve it the first time, he would then have been able to master without error the problem that he finally solved only after several so-called false or random attempts. This would have meant that the final, complex problem would have been solved in the end with much less wasted effort, without the setting in of any irradiation pattern. And what is still more important, he would be equipped for further progress to an extent incredible to the advocate of the try-try-again conception of learning.

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CHAPTER XIX

THEORETICAL PROBLEMS OF LEARNING

The Problem of Repetition

Rôle of Repetition of Response in Learning. As we approach nearer to school problems that are to be solved with the aid of Educational Psychology, it becomes necessary to take account of stock, that a full insight into the learning processes of the child will be guaranteed. Remember, the teacher is the Engineer of a delicately adjusted, organic system of energy that assumes the form of a personality. Misunderstanding the laws of this system, while guiding its development, means weakness of thought and achievement, and these, in turn, mean lost opportunity for which the teacher is responsible. These errors lie in mistaken conceptions of the way in which learning is conditioned. While these misconceptions have been encountered all along, it is worth while to inspect the experiments which have been designed *especially* to test them.

Repetition of response has always been regarded as a condition of learning. This view has been stated as the law of use, exercise or frequency by Thorndike [1] and others, and in general, means that when a certain stimulus arouses a certain response there is a connection or bond formed between them that is strengthened by the exercise so obtained, implying, of course, contiguity between the experiences concerned both with the stimulus and with the response. If this theory were true one could never explain how the organism makes progress between repetitions of response, which is the rule rather than the exception. Nor could we account for the fact that the learner makes sudden gains or losses during the performance of a given task, for, according to the repetition theory he is by definition doing

[1] Thorndike, E. L., *Educational Psychology.* New York: Teachers College, Columbia Uni., 1913.

the same thing over and over, no matter what the conditions, as long as he is repeating the act. Lastly, the repetition theory assumes that the learning process, a whole, can be built from its parts by addition and synthesis. That the whole cannot be accounted for in terms of its parts has already been demonstrated.

Illustrations of the Inadequacy of the Repetition Theory: Thorndike's Experiments. Many investigators have recognized the inadequacy of the theory that learning takes place by repetition of response, and among them Thorndike.[2] In a recent experiment which he performed, fourteen adults wrote 3,586 five-figure numbers which were dictated to them. They made no effort to remember any of the numbers. When the writing was completed they were given sheets containing many of the numbers written, but minus the last two, with the instructions to add them from memory. Numbers that had occurred 30, 36, 42, and 48 times in the original series were, respectively, completed only 5, 5, 3 and 10 per cent correctly. In another case, a typist copied a series of words each paired with a number, like bread-27. Ten minutes after she had finished copying the lists she was asked to write as many of the pairs as she could remember. *She had none right of the three occurring 48 times and three right of the 10 occurring 24 times in the list.* In this case materials that had been repeated fewer times were remembered better.

Peterson's Experiment. Peterson[3] performed an experiment, already mentioned, that disproved the repetition theory. He employed 20 subjects who learned to trace an imaginary maze in which there were many blind alleys. The procedure was so arranged that repetitions of stimuli were equally balanced for and against learning. That is, at stated periods in the learning, the subject had an equal chance of choosing the right or the wrong path at a V-shaped juncture. Some of his subjects learned the problem with striking rapidity. According to the frequency theory, the repetition of response would have hindered the learning process under the conditions prescribed by

[2] Thorndike, E. L., *Human Learning.* New York: Century, 1931.

[3] Peterson, J., "Learning when Recency and Frequency Factors are Negative." *J. Exp. Psy.,* 1922, Vol. 5, 270-300.

the experiment. *Pure frequency (and recency) factors should have produced chances that were 1024 to 1 against learning, yet in spite of this fact, learning took place.* It is evident that learning cannot be accounted for in terms of repetition (and recency) of response when learning can take place with such overwhelming odds against it. Moreover, that learning does not take place when the conditions are satisfied for the repetition theory, is also conclusive evidence against the theory.

Lashley's Experiment. There are many other sources of evidence that disprove the repetition theory. For example, Lashley's study of the monkey in which a latch box was opened, without error, with the use of a hand that could not possibly have been practiced because it was paralyzed by a brain operation, leaves no room for repetition of response as a factor in learning. This type of theory is based upon the assumption that habits are formed by reduction of resistance at the synapse, a conception whose logic dates back to ancient times. But, in the experiment by Lashley, the synapses which should have been 'practiced' in terms of this theory, had been destroyed or rendered incapable of functioning. Nerve routes that could not possibly have been exercised functioned perfectly the first time.

Why should it be expected that a synapse functions more easily after it is used than before? Only through a faulty conception of what the synapse does. It is a switch. When a current of electricity passes over a switch it does nothing to the switch, and it will traverse it as easily the first time as the millionth. A current of air need not tunnel a groove through the atmosphere in order to find its way into another part of the field. The apple need not repeat falling before its performance will be perfect. *Forces in nature, anywhere, do not require experience in order to function perfectly.*

Facts Against the Synapse Theory. *Returning to the synapse, the reason why a nerve impulse will or will not pass through a synapse is the reason why the impulse will or will not take place at all.* It depends upon differentials of potential in a field of 'fluid' energy. The nerve routes are merely paths of least action, whose functioning at any one time is determined by the character of the field that surrounds them. If there is a high potential behind a certain synapse and a low potential in

front of it, a nerve current will pass through as easily the first time as any time thereafter. We must look elsewhere for an answer to the question, How are habits formed?

Additional support of this view comes from the all-or-none law which indicates how the effect of resistance at the synapse is *made up* in the next neuron. Also, recall Lashley's experiment in which the rat, injured by an operation, could not make a left turn. In spite of this fact, it was able, the first time, to thread a maze previously learned by means of other co-ordinations, by making three consecutive revolutions of 270 degrees. There was no practicing of synapses here, with respect to the stimuli of the experimental situation. Remember Kuo's experiment in which rats forsook those paths, that had in the past been repeated most often and most recently, for different and more *direct* routes the instant the paths were perceived in relation to the goal. And finally, recall the works of Coghill, Carmichael, Bird, and others, on maturation. In short, the law of configuration and the law of least action preclude the theory of synaptic resistance as a basis of learning, and preclude repetition of response as a cause of progress. The very essence of learning is NOT REPEATING A PERFORMANCE, BUT MAKING A NEW ONE.

Rôle of Repetition of Stimulation in Learning. The question may now be asked, What is the function of repetition? Surely it must count. One must confront a new problem more than once in order to master it. It has been seen that the repetition *of response* is not a conditioning factor, but repeatedly confronting a situation provides the *stimulation* that is necessary for maturation. It has already been noted, in connection with pacing, that when a problem too difficult for the learner is presented him, he perceives it in light of the insight that he possesses at the time, and then must be allowed to mature before he can solve the problem. He is not repeating performances when *he* is the point of reference, but *only when the completed task is the point of reference.* And the completed task can be the point of reference only for the person who sets up the problem *for* the learner, or when the learner himself *looks back* to earlier stages and compares them with the end product of the learning. Then it can be seen that the problem has been confronted re-

peatedly, but this is after, not before, the progress has taken place. One cannot reason *after the fact* and explain the fact.

The applicability of the stimulus-theory can be demonstrated in many ways. Stimulation can be overdone and as a result, an irradiation pattern will set in, which is detrimental to progress; thus, the relevance of stimulation to learning. The importance of the proper distribution of work and rest periods is further substantiation of the theory, for it shows that stimulation *must be judiciously applied in the learning situation.*

Repetition of the stimulus-situation relates to learning in another sense. The learner never confronts the same situation twice; he is perceiving a different stimulus-pattern each time the problem is presented, for the precise reason that *he has changed, as an organism, in the process of maturing.* This means that although by definition his behavior is always 'repeated' goal-activity, it is activity toward a different goal each time. Therefore, only in the sense that learning is, in the abstract, repeated goal-activity is there repetition. It is obvious, of course, that this is not the repetition of response that the frequency and recency theories presuppose, for the response is actually different each time. Repetition of stimulation then becomes a condition of learning because it induces maturation, when the stimulus-pattern is properly presented.

Repetition of Stimulation and the Dynamics of the Brain. The function of stimulation can easily be understood in terms of dynamics. No system of high potentials, surrounded by a field of lower potentials, will permanently retain its energy. A battery, if left alone, will 'run down.' A heated body will soon cool off if its surroundings are of a lower temperature. The air pressure in a tire gradually decreases when the air is not renewed. We have supposed that the energy of the brain, necessary for the execution of skilled acts, is aligned into delicate differentials of potential, and that these differentials are set up by stimulus-patterns. In the absence of these patterns the differentials in potential subside and the distribution of energy in the brain becomes homogeneous. Moreover, some of this energy will be consumed in the ordinary routine of living. This is why the skilled performer, like the violinist, the acrobat, and the diver, or the person who has learned a foreign

language, must 'keep in practice.' It is not that exercise keeps the proper grooves worn in his nervous system, but that repeatedly confronting the task, which is repeatedly confronting stimulus-patterns, is necessary if the delicate distributions of energy upon which the co-ordinations and memory depend, are to be maintained. With removal from the stimuli the most delicate differentials of energy are the first to be obviously dissipated and the corresponding delicate aspects of the performance are the first to disappear. As time goes on, and the dissipation of more energy takes place, the grosser aspects of the performance suffer measurable disturbances. By this time the products of many months, perhaps years, of maturation, may have disappeared. A similar type of disturbance is to be observed when the energy of the brain is dissipated by fatigue, drugs, disease, and emotional excitement or shock. The last co-ordinations to have been effected are the first to go. The older and grosser types of response, represented by more stable concentrations of energy in the nervous system, suffer their measurable changes last. Although the dynamics of this conception are new, the idea that the latest and most delicate acquisitions suffer first has long been recognized.

The Problem of Experience and Learning

Rôle of Experience in Learning. That we learn by experience is another major assumption which demands reinterpretation. The solution of a present problem is supposed to be explained by solutions of previous problems. This means that there is nothing new in learning, but only a recombination of the old, a view that presents numerous difficulties. First, there is nothing in the theory to explain *how learning commences.* How, for instance, does the learner make his *first* response in terms of past experience when there has been no past experience? If a theory cannot account for the first learned response it cannot account for the 10th or the 100th or the 1,000th! Second, the experience theory assumes that any new response is merely a combination of old responses brought about by the formation of new 'bonds.' Both fact and logic are against this conception. Suppose the alleged fact of 'combin-

ing' be inspected, and then, under a third point, the question of 'bonds' be considered. The most obvious fact about a learned response is its *newness,* which is not equal to the old responses summed together, for summing up the old will not produce the new.

In Patton's experiment the learner did not combine his old 'hunches' about the series of paired lights in order to derive the new theory that solved the problem. On the contrary, the new theory came suddenly, completely organized with no reference to previous ideas insofar as they might have been *part* of his *new* ideas. Peterson's subjects, working with the mental maze *did not combine* the experiences they had during the earlier course of the experiment, and from them obtain the sudden solution. This was impossible because the majority of the experiences up to this time *had been errors.* The sudden flash of insight that solved the problem came after, but was not something which the learner obtained *from,* past experience. Experience, then, cannot be the cause of learning. Snoddy's subjects, who traced a star pattern in a mirror, certainly did not learn by experience when the new movements they made were not the sums of the flexor and extensor movements made in the beginning. This is obvious from the appearance of the paths. They were new movements never made before, in whole or in part. The learner progressed when he had sufficient insight to balance opposed contractions of the arm muscles in the process of making a movement straight down the path. Then and only then did he experience the correct movement, and then *it was already learned.*

The Problem of Association. Third, the experience theory assumes that the learner associates the correct response with the situation in which it is to occur, by the formation of certain bonds. This would mean that the child, learning the alphabet, for example, associates the letter with the name of the letter, and each letter in a given position with every other letter until he has built up the alphabet piecemeal. But what happens when the child sees the letter *A* in the word *'CAT'?* He has no associations between the letter *C* as the first letter in a series and the letter *A* as the second and the letter *T* as the third. This is not the series he has learned as the alphabet. All the

associations formed, so far, are with the letter *A* as the first, *C* as the third, and so on. Does he then form new associations before he recognizes the letter *A?* According to the association theory he must, for he has never experienced the letter *A* in this situation nor in these relationships. Hence he would not be able to recognize *A* in the word *'CAT.'* As a matter of fact, however, he does recognize the letter *A* when he sees it in *'CAT'* and there must be a *first* time when this is accomplished, before there has been any experience with the letter *A* in this situation, or in other words, *before any bonds of association between the letters could be formed.*

The Substitute Explanation. The child had not in the first place learned by the formation of associations or he could never have recognized the letter. When he learned the letter originally it was not only a letter in the immediate situation, but a letter in wider relationships. It was the insight into this wider relationship which enabled the child to learn the letter originally and it was the same insight which enabled him to recognize it the first time it appeared in the new situation. The wider relationships are very abstract but very precise and definite. First, the letter *'A'* has a form of its own, different from all others, distinguishable, when learned, from other letters whenever and wherever found. Second, it has a property of 'being a letter' which it derives from the whole of which it is a part, the alphabet.

Third, the letter *'A'* is learned as a sound *relative to* other sounds. These, and many more properties, all give to *'A'* an individuality of its own which emerges out of a vast ground of pre-existing but less differentiated ranges of experience just as the pitch of a tone is perceived by virtue of its position in a pre-existing, but undifferentiated, range of tones. In this case the whole that determines, and gives properties to, its parts is a very complicated one, and in virtue of this complexity the recognition of the letter is immediate and certain. It was originally learned, therefore, through a differentiation process emerging from a visual, sound, spatial, temporal, and conceptual, ground.

The inadequacy of the experience theory as an explanation of learning, as well as the inadequacy of the association theory, has now been pointed out. What, then, is the rôle of experi-

ence in learning? The experience *is the learning; they are synonymous terms.* To say that the individual learns by experience is to say no more than that he learns. He cannot learn without experiencing any more than he can learn without learning and for the same reason!

The Problem of Trial and Error

So-called Trial and Error Learning. The exercise theory, the redundancy of which has just been shown, rests upon several troublesome assumptions, some of which have been discussed and disproved by the facts of experiment. One error leads to another. The error of the exercise theory leads to the illusion that learning, *in a scientific* sense, proceeds by trial and error. This problem came up at the end of the discussion of animal learning. It is necessary, here, to approach the same problem from other angles because it is so closely related to other conceptions, such as the stamping in of ideas and movements through satisfaction, and their stamping out through annoyance, which must be considered in their turn. The trial and error conception assumes that the learning process is, at first, random, and that correct responses are originally made by chance. This means, in turn, that if progress is to occur, correct responses must be selected and wrong ones eliminated. If they are to be selected and eliminated, agencies of some sort must do the selecting and the eliminating. Accordingly, the supposed agents are found in the stamping-in effect of satisfaction, attending success, and in the stamping-out effect of annoyance, attending failure. This latter theory is known as the *Law of Effect,* and will be inspected shortly.

Meanwhile, the trial and error concept in its own right raises objections for which there is no solution. The trial and error theory assumes that the learner is responding, at the outset and throughout the process, to the goal *set up for him* by an experimenter or some other external source. Exactly the opposite is true in all learning processes of any length. Recall the fallacy of the double standard, which can now be inspected more closely. The fallacy of this reasoning lies in the assumption that the learner is perceiving the same goal as that of the experi-

menter *and yet is reacting as if he did not perceive it.* The experimenter assumes what goal the learner is approaching and then denies that it is the goal by saying that the learner's behavior is random; for random activity, by definition, has no direction and no remote end.

The Inadequacy of the Trial and Error Conception Illustrated. A rat is placed in a maze by an experimenter. There is food at the other end but the rat does not know it. What will the rat do? Try to find the food trial and error fashion when he does not know that the food is there? Hardly. It perceives the maze either as something to escape from if it can, something to explore, or merely a place in which to sit down and wash its face. It goes into a blind alley, but it is blind only for the experimenter who constructed the maze and knows the location of the food. Yet the experimenter chalks down as 'error' and calls the rat stupid, saying that it must learn trial and error fashion. He assumes that, before the rat will find its way to the food, this move into the blind alley must be stamped out. Meanwhile, the rat wanders around; there is nothing for it to do but sit down, hunt for a way out, or for food. Wherever it was it would be hunting for food if it were hungry, consequently the hunting is irrelevant to the problem-situation as seen by the experimenter. Before it knows there is food in the maze it has gone into several blind alleys, and taken several minutes to discover, merely by chance, as far as *it* is concerned, that there was food in the apparatus. But, by this time several errors have been jotted down against it for being unable to solve a problem it had in no way perceived!

The rat has found the food. What does it do next? It is now under somewhat greater tension; it is hungry, but in addition, has a more definite goal; there *is* food in the maze; in an undifferentiated way it has perceived *where,* for it has been exploring the entire apparatus and has an undifferentiated perception of its size and arrangement. The maze has been too complicated to perceive in detail, however, but the vague goal, whose position is vaguely perceived, conditions movements that are more direct with respect to the food.

The experimenter notes that a few errors have been omitted and adopts the idea that they have been stamped out; supposes

that the more direct or successful movements have been stamped in. But instead, stimulation has differentiated to a slight degree a behavior-pattern involving a general perception of where the food lies. Had the plan of the maze been simple enough the differentiation would have been completed upon the first discovery of the food. But the plan is too complex. Just as, the first time, a novice cannot see all the details of stained tissue under a microscope, or the meaning of each detail on a page of Chinese script, so the rat has not yet perceived the maze in sufficient detail to run directly to the food. However, it has perceived enough to shorten its course under the law of least action. Continued stimulation causes these details to emerge, until at last the rat goes straight from the starting place to the food box. Proof of this interpretation can be found in numerous animal experiments, especially those by Gengerelli, already described. What satisfaction and annoyance may have had to do with the solution has already been discussed under the dynamics of emotion.

Is not hunting or searching a trial and error activity? When one fools away an hour on a Chinese puzzle is it not a random performance? Only in a practical or moral sense, not in a scientific sense. The fisherman, hunter and puzzle-solver are all doing the same thing. They are exhibiting activity perfectly organized under the conditions. The goal is general; there are many possible movements, for the fish, the pheasant or the solution of the puzzle may be at the end of any of them, but each one, successful or not, turns out to follow the same laws as the successful one. It is made with respect to an anticipated goal somewhere in a field. Each is made in relation to all the others; the performance is planned whether successful or not.

Difficulties with the Law of Effect. The law of effect, conceived in the necessity of explaining how order is brought out of a chaos of random and trial and error activities remains to be inspected. Numerous experiments have disproved it. In Snoddy's experiment in which the subjects traced a star pattern in mirror vision, the most rapid progress was made along the sections of the star that were the most difficult and the most annoying. There was no evidence, when these parts were learned, of any particular pleasure or satisfaction. In fact the

most pleasant parts of the star were those that were originally easiest to traverse. Accordingly, if pleasure were necessary for improvement the observer would never have made any progress. That he did make progress we know. Again a behavior-pattern was progressively expanding, and differentiating, under the laws of dynamics.

Peterson's Experiment in Relation to the Law of Effect. Peterson [4] has recently performed an experiment, using the mental maze that has previously been described, in which the factors of frequency and recency operated against learning. In the present experiment he submitted his observers to an *electric shock* whenever a *correct response* was made in the learning. One group of control subjects was punished on wrong responses only; another on certain right and certain wrong responses; a third group, also a control, was punished on wrong choices only, after successfully beginning the maze with punishment only on right choices. The shock was administered through the subjects' fingers and was sufficiently intense to be painful. If the law of effect is true, we should have to predict, in the case of the experimental group, that the successful choices would be stamped out, because the law states that painful responses are stamped out. But these were the correct ones; therefore, if the stamping theory holds, painful movements were stamped in, instead. In other words, according to the law, the successful responses should have been eliminated and learning could not have taken place. Nevertheless, *learning did take place,* under these conditions, in as short a time, and *in some cases shorter,* than when the shock was administered on the wrong response.

General Factual Evidence Against the Law of Effect. Consider other difficulties with the law of effect. This is important, because one's whole conception of motivation rests upon an adequate view of how feeling influences learning. First, before an organism can possibly be 'affected' by the satisfaction or annoyance attending its responses, *it must have* discovered the consequences of its responses; it must have perceived the correctness or the incorrectness of its choice with

[4] Peterson, J., "Learning when Frequency and Recency Factors are Negative and Right Responses are Painful." *Psy. Bull.,* (Abstract), 1931, Vol. 28, 207.

respect to something, and this something must have been the goal. Otherwise, the feeling had nothing to accomplish. If the organism perceived the relation of its choice to the goal, *then the act had already been learned;* consequently the circumstances necessary to make feeling efficacious as a special stamping in and out agency render feeling unnecessary. A beautiful self-contradiction!

Second, responses that are correct the first time are made in learning situations. In fact, *when the conditions are optimum this always happens.* Couple this with the fact that each progressive step in learning is the making of a complete, new response, and there is no opportunity for the law of effect to work. Each response is made *as far as its correctness is concerned,* independently of pain or pleasure.

Third, there is no known physiological mechanism by means of which the law could operate. In fact it violates all that is known about the nervous system by assuming that feelings have special effects on particular synapses or, what is more unintelligible, that the neuron somehow receives the effect by being forced to conduct when not ready, or being permitted to conduct when ready. The problem of 'readiness' is another which must be entirely reinterpreted, as will be seen shortly. Further, the law of effect is meaningless from a physiological standpoint because it cannot possibly explain how movements are selected that depend upon the simultaneous use of extensor and flexor muscles, and practically all movements are made in this way. For example, a dog is whipped for chewing a slipper. The pain is supposed to stamp out the chewing contractions, but they are executed, physiologically, by means of a dual type of nerve control, stimulation and 'inhibition.' When muscles are bringing the jaws together, one set, the flexors, are contracted, and the other set, the extensors, are relaxed. When the jaws are being opened the opposite is true. Pain is supposed to prevent the jaws from closing upon the slipper. If it accomplishes the double function of inducing extensor adjustments and inhibiting flexor adjustments, it is doing what the law of effect states that it does not do, namely, *stamp in* a given set of muscular movements, for part of the dog's response is a positive muscular adjustment.

Fourth, the law of effect is meaningless because it entirely begs the question, How does the movement that is stamped in or out acquire its *direction?* The pain or the pleasure, certainly, cannot give the movement direction since it comes with it or afterward. In reality the act already had direction before the satisfaction or annoyance was felt. This is the fundamental weakness of any law of association; it takes the direction of a response for granted, which is the kernel of the whole problem. Even if the pain or pleasantness came with the movement, it could not provide the direction unless endowed with a mind of its own. Direction of movement can be explained in only one way, namely, by a law presupposing a field of energy differentiated into potentials, where each movement has a beginning and a remote end established at the same time by the same set of conditions.

What then, precisely, is the relation of pleasantness and unpleasantness to the learning process? These processes are symptoms, not causes, of energized learning. They are to be treated as a physician treats symptoms of disease in the sense that they are to be placed under control. Pleasant learning is to be induced by setting up the proper conditions, such as a desirable goal, but always one where achievement can be its own reward. The truly pleasant learning is learning for its own sake, rather than for an ulterior reward. Unpleasant learning is produced by setting up goals to be avoided, and again, avoiding the goal must be its own reward by ending in achievement that has intrinsic value. Where the rewards and punishments are side-issues to the learning process the learning is bound to be superficial. Pleasure and annoyance, then, correlate with learning just as pleasure correlates with good health and pain with ill health. In no case is the one the cause of the other. Pleasure and annoyance are symptoms of efficient or inefficient learning as the case may be. Feeling and learning belong to the same behavior-pattern having a common cause, the stimulus-situation and the degree of maturation of the learner.

The Law of Readiness. Thorndike [5] has attempted to explain why pleasantness and unpleasantness should affect the learning process, by an appeal to another law, namely, the law

[5] Thorndike, E. L., *op. cit.*

of readiness. When neurons are compelled to conduct impulses they are either ready or unready, according to this law. If they are ready to conduct it is pleasant; if they are unready to conduct it is unpleasant. Is this theory workable in terms of dynamics? A wire, a neuron, or any conducting medium, is neither ready nor unready, except as it exists or does not exist. Whether it will conduct or not depends upon surrounding conditions in the field of which it is a part. Moreover, it makes no difference to the wire or to the neuron how much resistance it offers to the process of conduction. It is always ready to conduct at a maximum under the existing conditions and that maximum depends, among other things, upon its internal structure. It is just as 'easy' for a wire to conduct when it offers great resistance as when it offers little resistance. Conduction, after all, is not a matter of 'ease,' but a matter, again, of dynamics.

We may interpret 'readiness' dynamically, but only as a derived property, a potential that depends upon a differential, so that there is a demand for equilibrium. This demand may be called 'readiness' if so desired, but it hardly adds anything when potential intrinsically means 'readiness' at all times, given the differential.[6]

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[6] In his recent book, *Human Learning*, Thorndike has approached in certain respects toward an organismic conception of learning, especially in his use of the concept 'belongingness.' He has subordinated the law of effect to 'belongingness' and has questioned the law of frequency. His position is a confused mixture of configurational principles and incompatible, associationistic principles. His law of 'belongingness' is a recognition of the configurational principle of membership-character, expressed in this text, as the law of derived properties. Yet he treats responses, supposed to have the property of 'belongingness' in larger wholes, as if they did not have, in reality, a derived property, but one of their own. He still envisages them as independent units of behavior that must be 'connected,' under the assumption of a lack of organization in the beginning. This treatment of the problems of behavior results in the curious paradox that organization is something to be explained and yet something to be assumed.

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CHAPTER XX

A SUMMARY AND INTERPRETATION OF LEARNING

The Interpretation of Learning Curves

Types of Learning Curves. Progress in learning is ordinarily measured by means of a curve. This curve can be plotted in various ways, consequently the kind of progress that is being measured is to a large extent dependent on the way in which the results are plotted. One method of plotting the results of a learning experiment is to represent successive trials by units along the base line (abscissa) of the graph and to represent amount of work done per unit of time by units on the verticle (ordinate) axis. A curve plotted in this way will commence relatively low and ascend to a point where the task is learned (Fig. 43A). A second method is that of representing successive decreases in errors on the vertical axis and trials on the horizontal. This type of a curve will start relatively high and will descend to the point where the problem is learned (Fig. 43B). Third, time (or distance travelled) may be plotted on the vertical axis and trials on the horizontal, giving a descending curve which represents increase in efficiency (Fig. 43C). Fourth, time may be plotted on the base line and amount of work done per unit of time on the vertical axis, giving an ascending curve (Fig. 43D). Where trials or time are plotted on the abscissae, the ordinates may represent percentage of correct responses, average number of responses per unit of time, or absolute amount of work done per unit of time. That there are these ways of plotting progress in learning and many others besides, means that, in order to make a declaration about the rate of learning, one must always bear in mind the units of measurement.

The Learning Curve as a Chance Curve. The learning curve presents many difficulties of a serious character. The

pertinent question might be asked, Is a curve a representation of actual learning or does it portray the subject's performance under chance conditions? As we have pointed out in connec-

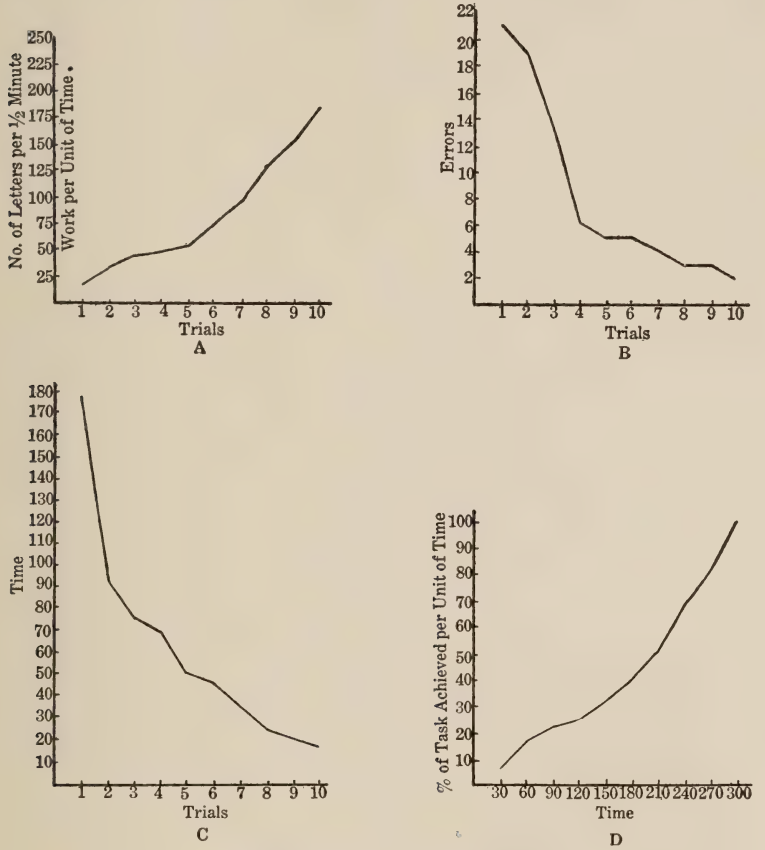

FIG. 43. DIFFERENT TYPES OF LEARNING CURVES.

The data consist of hypothetical results on learning to typewrite. All curves are computed from the same set of data. Units are arbitrary.

tion with pacing, if the conditions of learning are sufficiently under control the learner should solve the problem at the first attempt. Under these conditions we obtain a 'learning curve' which has absolutely no length with respect to trials because there is only one trial. This hypothetical 'curve' does not represent a learning curve in the ordinary sense of the term, yet it is a representation of learning under the best controlled condi-

tions. A curve obtained where more than one trial is involved in mastering a single task (*cf.* Fig. 43) is a sign that the task is too difficult. What the curve represents, therefore, is not learning on the part of the subject, but an irrelevant, artificial performance, a product of inadequate conditions imposed upon the learner. As a consequence, the graphic representation of this performance is no more than a chance curve.

The shape of the curve represents the rate at which chance conditions have been eliminated, or the rate at which the experiment brings the behavior of the subject under control. Proof of this view is found in the fact that when the learner is first presented with a task, his behavior *cannot be predicted,* whereas, after he has progressed to the point where he has learned the task his behavior *can be predicted.* Obviously, at the outset, when a complex situation is strange to the learner, and too difficult, the time or the errors that are supposed to measure what the learner is doing, *relative to the imposed task,* cannot mean anything else but lack of control. The learner is simply not responding to the stimuli as the experimenter sees them. Certainly, a situation too difficult cannot in the nature of the case be responded to. Instead, the learner responds to a simpler situation of his own, and the learning curve in no way informs us what the situation is. A measure that means only the extent to which chance conditions are figuring in an experiment, cannot be the measure *of what the learner is doing.* As a picture of learning, therefore, the curve is no better than an illusion. It represents the extent to which the experimenter *guessed wrong* in deciding upon the proper method and materials to use in studying the learner's behavior.

The Maturation Curve. There is, however, another type of 'learning curve,' which approximates a curve of maturation (Fig. 44). Curves of this type approximate the rate at which the learner maturates to the situation confronting him. That learning proceeds more slowly when repetitions are bunched, and also more smoothly when spaced trials are optimum for maturation, is a substantiation of this view.

Further substantiation is found in the fact that when curves of learning are made by plotting amount of work done in a given time against trials or successive work periods, we are in a

sense measuring the learner's normal rate of development as he selects for himself larger and more difficult tasks at each trial.

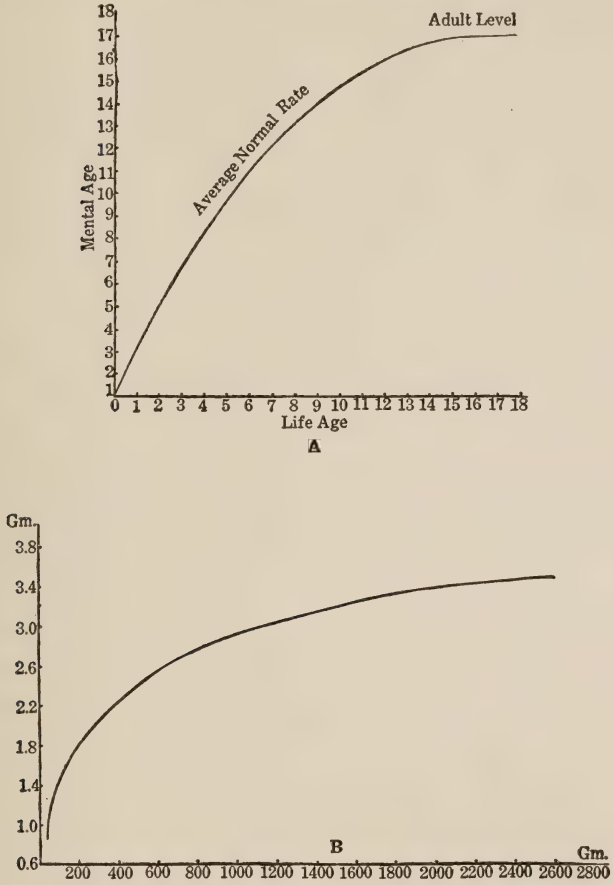

FIG. 44. 'MATURATION CURVES.'

(A) is a theoretical curve of the growth of intelligence (after Doll) and (B) is a curve of the growth of the chick's brain when brain weight is plotted against body weight (after Latimer). Note the resemblance to learning curves. By permission.

Under the right conditions, such a curve ought to be a genuine growth curve.

There are other advantages of considering certain learning curves, actually obtained, as approximate pictures of maturation. The concept of maturation makes meaningful the *spurts*

or sudden rises found in most learning curves. These spurts may be caused either by an interval at one time of longer duration than at other times, thus permitting more maturation, or, by conditions of stimulation during one interval that induce greater maturation than during another, or, by sudden motivation. These spurts in the learning curve are observable in the behavior of the learner as *flashes of insight,* which are perceptions of the task in new and wider relations. That the spurt may be located at any place along the course of the curve is evidence for the maturation theory, for, under the chance conditions of experimentation the *spurt could* appear anywhere. Where it would appear depends on how well the experimenter has fitted the problem to the learner.

Courtis on Learning Measurements. Other methods and conditions of measuring a given learned response are found, when analyzed, to effect the curve. Courtis [1] has measured in different units and under different conditions, performances that did not improve noticeably during the course of the experiment. He first presented a 25-year-old subject with nine tests in handwriting. The conditions for each test were different, such as writing as fast as possible, without regard to quality; writing as well as possible, disregarding rate; writing rapidly and well. Each set of results was different as regards both rate and quality, ranging from 20 to 75 units in quality and from 51 to 143 in rate. These results would indicate that handwriting, although a well-learned and stable response, is at all times dependent on the conditions under which it is tested, so that the resulting picture at any one time is directly dependent on these conditions.

A further experiment was performed on 1500 children who were presented with the same handwriting tests, eleven times, under different conditions. The same task, executed under differing conditions gave an average variation in speed from 38 to 98 letters per minute, and 21 to 61 in quality. It would be possible, if a sufficiently large number of tests were given under different conditions, to make a *map of the variability of possible scores* for a given individual. The danger of taking any

[1] Courtis, S. A., "The Relation Between Rate and Quality in Educational Measurement." *J. Educ. Res.,* 1924, Vol. 10, 110.

one score in this range and comparing it with a score of another individual anywhere within his range is at once apparent. Unless we have scores of the two individuals obtained under approximately the same conditions, the attempted comparison will be meaningless. But we can never assume that the experimental conditions are comparable when individuals are the points of reference. Courtis measured the error of comparing two individuals when their scores were picked at random from this range. For example, individuals A and B, with a single trial as the point of reference, appeared to differ in ability by about 10 points in rate and 30 points in quality, *with B the more able.* When, however, their 'fields of variation' had been studied and comparable scores selected, they differed less than 5 points in rate and 10 in quality, and *A was better than B!* (*Cf.* Fig. 45.)

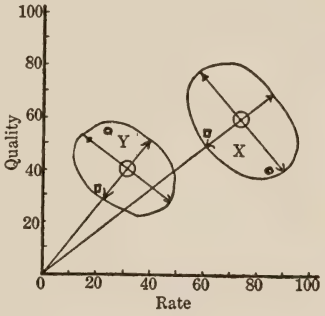

FIG. 45. TYPICAL FIELDS OF DISPERSION IN SCORES OF TWO INDIVIDUALS, X AND Y (After Courtis).

If scores for X and Y, such as the two circles, are compared without reference to the conditions under which they were obtained, Y is better than X. But when points that correspond in the two areas, such as the two squares, are compared, X is better than Y. By permission.

A Warning Concerning Curves. All this indicates that the learning curve is a most dangerous object to interpret. It is always dependent first, on the methods and units used in its plotting. The same learning process will appear to be fast if plotted one way, slow if plotted another, accelerated or decelerated in rate of progress, or neither, as the case may be. And they are all pictures of the same learning process studied under the same conditions! Second, any test of learning is dependent on the conditions obtaining at the time the test is made. This means that the *same learned response* may be tested under varying conditions and different curves will result, even to the extent of indicating contrary results. Third, in comparing results of two individuals in the same kind of activity, corresponding points in the range of possible scores for both individuals must be considered in order to obtain a reliable

comparison. As Courtis has shown, the range of possible scores may be very great. These results mean that a learner never makes a response at one time comparable, exactly, to a response at another time; rather, the learned response is always made with respect to a highly variable and complex stimulus-pattern, as relative to the conditions existing at the time of the testing as to a given level of performance. Therefore, the measurement may describe a level of performance, or a set of conditions, good or bad. That is to say, *the curve may measure how well the learner is doing or how poorly the conditions are under control. One never knows from the curve, alone, which it is.*

The Organismic Laws and the Learning Process: Review and Applications to Education

(1) The Law of Field Properties: Insight. Once before, the important facts about learning were systematically brought together under eight or more organismic laws. Since then, many additional facts have been ascertained from a study of experiments on human, adult learning. These remain to be summarized and interpreted, for convenience, in the light of the same laws. The law of field properties means that learning is a behavior-pattern 'of one piece,' whose basic characteristic is *organization.* The details of the process cannot explain the process, because they are determined by the organization. The organization of the learning process is represented in the behavior-pattern by *insight,* when one thinks of the pattern from the standpoint of the learner's experience. Insight, thus defined, is a field property common to all learning-patterns. Several criteria point to its existence, and were discussed from time to time.

Form in Learning: Initial Delay. Other evidences of the law of field properties appeared, important among them, first, the phenomenon of *initial delay.* The initial delay is the time required for the organism to construct an organized perceptual pattern of the problem to be learned. Upon it the next step in progress depends. In other words the pattern must be formed as a totality, before the ensuing movements can be made toward the goal. It is a period during which the re-

sponse, whether seen as a perception on the part of the learner, or as a movement-pattern, is acquiring *form*. Guilford's subjects hunted for logical *form* or *plan* in the columns of numbers they were to learn; Patton's subjects looked for it in the order in which paired pairs of lights were presented to them; Snoddy's subjects had to see, as a whole, the path of the maze to be traversed in one movement, whether the path was restricted or extended; Peterson's subjects could solve the mental maze problem only by perceiving its complicated *form*. Again, the whole method proved superior because it took advantage of the form of the material *as a whole*. Gengerelli's rats took the shortest path to the goal as they had discovered the form of the maze as a whole. *The learner must in any case perceive the problem as a whole or he will not solve it; if the material is so selected that form or plan can be easily perceived, then the problem will be learned more rapidly, because the subsequent organization of responses having to do with mastery develops at a faster rate and proceeds to greater lengths.*

Temporal Pattern in Learning: Rhythm. Second, the law of field properties is illustrated by *temporal* form as opposed to the more *spatial* type of form just described. Temporal form is found in the phenomenon of periodicity or rhythm, and appears in various kinds of learning. Rhythm is a field property, which, like all others, cannot be accounted for in terms of the successive acts observed within it. It is at first a *gross temporal* pattern. For example, bodily activity is rhythmic, as was observed in Richter's experiment on hunger and on other cycles, and as Wheeler and Sarvis observed in blindfold maze tracing. Nothing affects these rhythms without disturbing a *complete* cycle. Moreover, the fact that the same rhythm can be detected by measurements of activity in different parts of the body, and by imposing different kinds of tasks upon the performer, indicate further the whole-and-field-character of rhythm. The temporal form which rhythm furnishes to poetry, music and dancing, and a modified type of rhythm characteristic of study outlines, in which minor points regarding the subject matter are systematically subordinated to major points, give to these various tasks a unity and coherence which make them easy of mastery.

Maturation in Relation to Field Property: Illustration from History Lesson. Again, *maturation* is to be understood in light of this law. The trend of maturation cannot be accounted for in terms of minor and temporary responses that the learner makes. Coghill observed this fact in the growing embryo. A physiological gradient or pattern, the property of a field, gives the details of the maturation process the particular direction which they take. Accordingly, let a student be assigned a history lesson on the Civil War period. He must eventually understand a great many incidents, names, dates, battles, in light of major economic, political and moral problems which confronted the country as a whole. Important among these problems was the question of States' Rights. The student who learns and understands the most undergoes a continuous, orderly maturation process *with respect to a major issue* whose meaning expands and differentiates day by day with respect to the achievements, personalities and temporal relations of incidents about which he reads. The maturation process is one unit in time from its beginning to its end. Its unity and coherence are measured by his answer to the question, "How much do you know about the Civil War?"

Irradiation Patterns. And finally, *irradiation patterns* come under the same law. It is true that the irradiation pattern develops because the trend of maturation has been diverted or has ceased entirely; nevertheless, the irradiation pattern is no less a picture, momentarily, of the total energy field of the organism; it describes that field under conditions when, for the moment, there is no growth. The irradiation pattern is a field property which gives to details of the learner's behavior at the time their characteristics, such as lack of interest, inability to see detail, and fleetingness.

(2) The Law of Derived Properties: Goal. The law of derived properties states that parts derive their properties from the whole. A *goal,* perceived before activity takes place, derives its property of 'goalness' from the perception of the total task which the learner constructs during the initial stage of the learning process. What the goal will be, and where it will be located, are both determined by the organization of this pattern. The *path to the goal* is also derived from the organiza-

tion of the total pattern, set up at the beginning of the learning process. Which pathway to the goal will have the property of being wrong and which path will have the property of being right can be discovered only in this way, and the right and the wrong paths must be apprehended in one totality of grasp. Rightness or wrongness of path, or method, does not come before the goal is perceived; there must be an understanding of the problem sufficient to give each minor attempt at progress all the properties that determine its relevance, correctness, and adequacy.

It was said in the preceding section that an *irradiation pattern* gave to the learning process its undesirable features of lack of interest, monotony, and general inability to see detail. These features, therefore, are derived properties. Where the irradiation pattern will come depends upon a totality of conditions under which the learning is taking place. Among these conditions are the distribution of work and rest periods, length of task, difficulty of task, definiteness of goal, and relation of the problem to the learner's degree of maturation. Thus it is, that no one characteristic of a response, either partly or completely learned, either desirable or undesirable, can be understood or controlled until it is studied in the vast whole from which it derives its properties.

The Whole Method. Learning abounds in examples that demonstrate this law. The *whole method* of learning proved the best because each detail of the material has no meaning in its own right. An idea in a poem, or prose assignment, derives its logical meaning from the plot of a story, an argument, a complete framework of thought; an objective in a maze, or in any situation where muscles must be co-ordinated toward a particular *place,* derives its property of *position* from the learner's perception of a total space field; the exact time when a given group of muscles should be contracted in order to complete a complicated act derives its position from a time-judgment of the duration of the total act. Thus, *just when* to twist the wrists in swinging a golf club, change one's posture in a drive, press a particular finger in writing a word on the typewriter, or strike a piano key in playing a melody, is in each case a *position in time* derived from the dynamic dependence of the

act upon the organization of the total performance. The execution of the minor act cannot take place, therefore, prior to the formation of the total movement-pattern.

(3) The Law of Determined Action. Applications of determined action to the learning process are legion. One of the most important aspects of a learned response is *direction.* In *muscular co-ordination* the problem is: What particular movement will follow after another; which muscle will contract first and which second; what conditions the order and the direction of the 'sequence'? In *mental activity* the problem is: Which thought will follow another thought, and what is to determine the direction of the total stream? These questions can be answered only by applying the law of determined action. The dynamics of the whole condition the *direction* of the particular movement or thought, and the direction of the total sequence. The contraction of a particular muscle occurs because the nature of the total movement-pattern is giving to it a certain value or function.

Problem of Selection in Learning. A particular movement is not selected from a number of possibilities and *put into* the sequence; it emerges from the continuous movement-pattern, related with its antecedent and consequent movements, as it appears. In Snoddy's experiment, the muscular 'set' assumed in a period of initial delay was a unified pattern of muscular tension to be 'unfolded,' *in one act,* as a consequence of the further stimulation received as the tracing process went on. The nature of this pattern, undifferentiated at first, determined the direction of each subsequent movement and the manner in which the movements followed one another toward the goal of completion. In Guilford's experiment the order in which each number of the series was to be recalled depended upon the learner's awareness of the plan on which the entire column was constructed. Thus it is, that when an error is made in recall it is caused by an inadequate conception of the material in its organized totality.

Interrupted Tasks. In the experiment on *interrupted tasks* the fact was evident that activity toward a goal was already determined before any detail of the solving process took place. The completion of the interrupted task had already been

provided for, before the task was under way. This meant, upon its interruption, that the learner was left with an unresolved tension, maintained by the relations of the original task to the stimulus-pattern to which he was responding in the meantime. *If the end of the performance had not been provided for at the outset there would have been no reason for the tension to continue when the learner did not reach the goal, for the tension and the goal must be set up simultaneously, or neither exists.* The one depends upon the other as a high potential depends, for its highness, upon a low, and *vice versa.* The tension, the goal and the path to it had been determined while the subject was apprehending the task in the beginning. Interrupting the task merely operated as an obstacle; it did not remove the goal or resolve the tension. The tension, therefore, still demanded resolution.

Initial Delay: Work and Rest Periods. That *initial delays* of *some sort* are necessary in every learning process can also be understood under the law of determined action. If the details of the process that are to follow are not guided by this pattern, but occur only in a chance order, there is nothing to give direction to any part of the performance. Imagine a diver descending from a high platform without having 'rehearsed' in advance the 'feel' of the entire movement-pattern that must unfold with unerring precision. One needs only to picture his helplessness when a prankish companion shoves him off unexpectedly.

It is also important to remember that the character of the learning process-as-a-whole determines the most effective position of the *work and rest periods.* It is for this reason that *the optimum distribution of work and rest periods in learning changes with the growth of the total learning-pattern.*

(4) The Law of Individuation. The maturing pattern of a learned response is constantly becoming more complex in the sense of becoming more detailed. *This increase in detail is, first, a differentiation process which is the result of proper stimulation.* The differentiation process takes the form of *emergence* of details, which, as they emerge, already have *membership-character* in the total pattern. That the character of the total pattern determines the direction of this differentiation

process must not be forgotten. Second, *the increase in complexity* is an expansion process. The learner's perception of the problem expands to a larger whole in which its parts take on a greater variety and complexity of relationships. His motor co-ordinations expand in intricacy of pattern as skill develops.

Dynamics of Skill: Increased Subordination with Differentiation. Where the *development of muscular skill* is involved in learning, the first performance is gross and 'awkward'; this means only that it is *undifferentiated.* The skilled responses characteristic of the later part of the learning process come as a result of a differentiation process from this original response-pattern which means an increase in complexity of finer muscular adjustments, but at the same time *a greater subordination of the refined movements to the total pattern.* Proof that the greater subordination of the part takes place in differentiation comes from the fact that when any little movement is changed at this stage there is greater destruction done to the organization of the total performance than at an earlier stage. Thus, if the expert golf player changes his stance ever so slightly as he is set for a shot, the result is an awkward movement, whereas, had he been an amateur the same amount of change would not have made the difference between a good and a bad shot. This is because the expert's nervous system is very delicately adjusted in all parts. Small differentials in potential are about to be resolved into the delicately executed movements having just the right *nuance* of forces and temporal relations. The novice's responses, on the other hand, are grossly patterned. A slight shift in adjustment is absorbed through the system without the production of a serious disturbance in the mutual relations of the pattern.

Form and Transfer. The emergence of *form* is another illustration of the law of individuation. The first perception of form is gross in character yet it covers the whole of the situation perceived. One part is as undifferentiated as any other. The perceptual pattern, however, is just as well organized, just as much a unified whole at the beginning, as after the details have emerged. These facts were pointed out in connection with Guilford's and Patton's experiments.

Transfer of training also illustrates individuation. The de-

tails of response, in the situation to which the 'transfer' has been made, emerge from the previously learned total behavior-pattern through a differentiation induced by the changed stimulus-situation. The emerged details of the original response and the new one are both differentiations from the same pattern. It is only when the two sets of movements, or the two sets of ideas, or methods of analysis, are members of the same whole and can differentiate together from that whole, that 'transfer' takes place.

(5) The Law of Field Genesis: Maturation. The general development-trend in the learning process that we call *maturation* illustrates the law of field genesis. Although maturation, in the long run, is a gradual process *the total pattern is new throughout each progressive step.* This means that the learner always perceives the *whole* problem differently each time he approaches it anew; the total learning-pattern has changed between one presentation of the task and the next.

Correcting Errors of Response. Improvement does not come about by adding a new idea or a new movement to a fixed pattern of ideas and movements. When a new response is made it means that *the character of the total performance,* acquired up to this time, has undergone a change. An error or inadequacy cannot be corrected, therefore, by subtracting or adding. The golfer cannot overcome a slice by centering his effort on an isolated characteristic of his swing. He must correct his entire pattern of action from the 'address' to the 'follow through,' because his error depends upon the lack of dynamic balance between all the aspects of his body posture and manner of swinging. *There are no local movements.* What appear to be local movements are integral parts of a differentiated posture.

Again, an error in spelling a word cannot be corrected until the 'feel' or the apprehension of the correct word as a whole is achieved because the value of a particular letter in a word depends upon the structure of the word as a single unit. A person who has memorized a poem by the part method is helpless when he forgets a passage. He has no tool by means of which to reconstruct the missing lines. The progressive mastery of any task is the evolution of a total pattern, perceptual and

motor. The *form* of the pattern is a unit from the undifferentiated stage at the outset to the differentiated stage at the end.

Insight. The phenomenon of *insight* demonstrates the law of field genesis, for insight depends upon a host of stimuli functioning at the same time. This multiplicity of stimuli does not produce a multitude of discrete and isolated 'sense impressions' and movements on the part of the learner, but a balanced, interrelated total adjustment in which no single aspect corresponds to a particular stimulus. In Patton's experiment there were two pairs of light stimuli presented at one time. In each pair there was a darker and a lighter disc. Suppose we give the four lights that are exposed at any one time the values 1-2 and 3-5, respectively, to represent their brightness. At another time the values are 1-3 and 4-5. The problem is: Respond to the pair that has the greater difference between the lights. In the first case, number 1 has the value of being in the wrong pair; in the second, it is in the correct pair. If the observer used number 1 as his cue he would make an error the second time. Number 3 is correct in both pairs, this time; but when it appears in a pair with 2 or 4 it is wrong because the other pair will have a difference of at least two steps. Thus the isolated stimulus has no value in its own right. The learner's organized response to the total stimulus-pattern, wherein the individual lights had to be perceived in their relationships, determined how he should perceive each light. Such is the type of response that evolves as a single whole. At no stage in its development from its original undifferentiated condition to the final differentiated stage is there a one to one correspondence between parts of the stimulus-pattern and parts of the response. The view that commits the error of making such an assumption is called the *constancy hypothesis.*

(6) The Law of Least Action: The Goal. The importance of the *goal* has been apparent all through our discussion of mental development. It is the low point, in a field of action, toward which activity must take place if it occurs at all. *Proof of this lies in the fact that no learning takes place until a goal is perceived.* It is important, therefore, that the goal given the learner be explicit and definite enough for him to perceive at

once. Failure in this respect will inevitably mean reacting, on his part, to a goal that is extraneous to the problem at hand.

Motivation and Least Action. *Motivation* has significance under the law of least action. The tension set up at the beginning of the learning process, when the problem is perceived, is the high potential which must be resolved by an arrival at the goal. This tension will be resolved in the most direct fashion under the existing conditions. If the learner's potentialities for action are set up with reference to some other goal than that of mastery in itself, activity will inevitably take place in that other direction, as a least action response. This means that rewards and punishments *must be* potential raising devices that do not become goals in themselves, or learning suffers in proportion.

Length of Learning Material. The law of least action explains the problem raised *by length of learning material.* Strange as it sounds *the easiest material to perceive, under a given set of conditions, is that which makes most explicit the relations involved, and this is the longest and most abstract material which the learner can adequately grasp.* Any response, under the conditions for least action, will complete itself as far as possible. Shorter passages than can readily be attacked restrict the learner's grasp of relations and mastery of detail, especially for permanent retention. Failure to apply this principle results in laziness and indifference on the part of the learner. An illustration of this fact is seen in the college student who finds his assignments and the curriculum too short and too superficial, and therefore too uninteresting, to justify the time and energy spent in the institution.

The Whole Method. The same fact came out in studies of the whole-part method, for, when the learner was given short and meaningless tasks, the 'part' method, so-called, proved convenient. There was little form or totality of meaning to be perceived. Here the line of least action was to follow the method of learning that the subject was told to use. But when *longer* and better *formed* tasks were presented, involving a logical plan, or a definite pattern of some kind that could be developed by means of rhythm, the learner relied upon the *plan* and therefore upon the *whole* method.

That the procedure, just described, is a matter of least action lies in the fact that the tension under which the learner is working demands *completion of resolution. Since, under the law, the learner is always approaching the goal as fast as he can under the existing conditions, it means that he must comprehend as much as he can.* Shortly it will become evident that the law of least action, as applied to learning, is intimately related to the law of maximum work.

Speed in Learning. *Speed* in learning means better recall. This, too, is reasonable under the law of least action. The learner with the higher tension at the outset will relieve that tension in the shortest time possible, and over the most direct route. The greater the tension the faster the resolution. But this is not all. *Under least action the faster the resolving process the higher the type of organization in the field of energy that is returning to equilibrium.* The more efficient methods used by the fast learner are always more complicated than the less efficient methods of the slow learner. If the rapid learner did not make more complicated responses he would be making the task harder for himself than necessary, and this he never does. As it is, he learns faster, learns more, and retains better, all under the law of least action.

(7) The Law of Maximum Work: Motivation. The fact that *motivation* is important in the learning process can, again, be explained, but now under the law of maximum work. The learner, under motivation, has a greater tension set up at the beginning of the learning process than when motivating stimuli are not used. This means that the *status quo* of the organism is under *greater* jeopardy. The greater tensions demand a more vigorous effort to reach the goal. It is to the greater interest of the learner, when motivated, to work harder, otherwise he suffers disturbances that are not compensated for. *This is why the highly motivated individual must complete his task, for otherwise he is bound to be restless and unhappy, and as a field of nervous energy, unbalanced.* Unless permitted to reach his goal he revolts. This point is of vast importance in understanding the energetic child or maturer student who *must often* accomplish more than the educational system, and his re-

lation to it, permit; it is a strong argument in favor of flexible rules, and the availability of project courses.

Initial Delay. The *initial delay* is seen again, as a vital phenomenon, under maximum work. The learner is constructing a perceptual-motor configuration of the activity that is to follow. Unless this period is long enough for the entire pattern to be formed, in outline, the consequences are fatal to the *entire* response. The pattern must complete itself to a maximum, under the conditions, before the explicit response commences. When anything interferes with the completion of this pattern the learner is not ready to perform the act, if it is a motor performance; or he forgets what he was about to do, if it is an ideational performance. Then he must commence his preparation for the act all over again or spend considerable energy trying to recall what he has forgotten.

Pacing: Work and Rest Periods. *Pacing* is an application of maximum work and makes use of *work* and *rest* periods. It prevents an over-stimulation that holds maturation at a dead level or worse and produces a plateau or decline in the learning curve. Patterns which remain relatively the same are 'wasted' motion in that they are avoidable. Pacing follows the law of maximum work, therefore, in that its efficacy depends upon setting up conditions for maximum progress. *Its value hinges on the fact that the organism demands any set of conditions that increases its maximum output and will always take advantage of them to the fullest possible extent.* Not to pace means only one thing, disintegration of the learning-pattern. This comes, (1) through the consequences of under-stimulation, which are degeneration of the pattern to more primitive (but no 'worse' scientifically) levels of organization, and to simpler, cruder and more sluggish responses. (2) It comes through over-stimulation and the consequent dissipation of the pattern into intensified action without effective co-ordination. Both conditions are characterized by the loss of differentials in the nervous system, that is, by a change toward stereotyped behavior.

Length of Material and Speed. Again, that *material* should be as long as the learner can possibly grasp is a condition of learning demanded by the law of maximum work. We have already seen that it was demanded by the law of least ac-

tion. If the material is too short the most efficient methods cannot be employed, and energy systems demand maximum efficiency at all times.

The *speed* factor in learning is likewise demanded by this law. The learner is always trying to master the problem as rapidly as he can, under the existing conditions, in order to be returned as quickly and as completely as possible to a *status quo.* This application of the maximum law, that the fast learner should be given *more to do* than the slow learner, will be mentioned again. It is of special significance in the management of the precocious child.

(8) The Law of Configuration: Goal. This law demands that a *goal* never be an isolated factor in the stimulus-situation. Furthermore, any stimulus in the pattern, other than the goal, is responded to only in its relation to the goal. And finally, insofar as the goal is a perceived *locus* in the external environment of the learner, it can only be a locus when at the same time the rest of the stimulus-pattern is perceived and understood.

Whole Method. In connection with *methods of learning* it was observed that the whole method or a modification of it was the most successful. The whole method is demanded by the principle of configuration. By the 'part' method the learner is responding to a number of smaller stimulus-patterns which he must perceive, later, as members of a coherent task, but its coherency has not been observed. The recall, therefore, depends on efforts to make the task coherent under the handicap of a memory that is always independable. This means wasted time and energy. The whole method avoids this dilemma.

Retroaction. Under '*temporal relationships* in the learning process' further illustrations of this law were found. For example, in *retroactive inhibition,* the learner perceived, *as members of the same learning-pattern,* in an undifferentiated way, *two tasks,* an original and an interpolated task. If the interpolated task was like the original there was interference when recall of the first task was required. The learner was in an unresolved tension relative to the first task; this was partly resolved in the performance of the similar, interpolated task. The partial resolution depended on gross relationships between

the two tasks. These relationships permitted partial completion of both recalls toward a single goal. But each of the two tasks was sufficiently different to demand completion toward a different goal not set up by the experimental situation. This was because the situation did not furnish the separate but interrelated stimulus-patterns upon which the two completions depended. On the other hand, when the tasks were sufficiently different to be completed by the functioning of separate stimulus-patterns, there were no partially interlocking interrelationships and no retroactive effects.

Transfer. 'Transfer' obeys the law of configuration, as seen when the maximum effect took place if the learner could perceive the tasks as members of the same configuration. Similarly, in so-called cross-education the learner is making a unified response to a total situation. The whole organism is performing with respect to the goal otherwise the left hand, for example, would not 'improve' when the right was being 'used.' The improvement in the unused member depended upon the type of situation as was described for retroaction. The retroaction meant inefficiency, however, because the experimental situation prohibited two responses (recalls of two sets of data) from becoming one act while in transfer the situation required it.

Incidental Learning. In *incidental learning* the law of configuration was evident. The learner was responding to a stimulus-*pattern* and not to isolated stimuli. He did not respond to series of numbers as such, or to any particular problem as such, but to the problem in relation to all other stimuli at the time, many of which were not explicitly remembered. It was this response to the larger stimulus-pattern that became the incidental learning. The facts of incidental learning indicate that it is one of the major practical problems in educational practice, for more is learned in the course of solving problems, with no emphasis upon intent to memorize minor and insignificant relationships, than under conditions of drill.

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CHAPTER XXI

THE PROBLEM OF MEMORY

Background of the Memory Problem

Memory and Learning. How is it possible for a learner to make progress in a given task from one presentation to the next? How can the learner go on with the task from where he left off after a rest period has been introduced? This leads to the problems of memory and forgetting, and therefore, to a study of the conditions under which experiences are recalled. It is obvious that 'learning' is another way of looking at memory, for learning cannot take place unless the subject can remember what he has learned. The practical questions then arise, Under what conditions does a learner recall most accurately? What influence has lapse of time upon recall? Under what conditions does the observer forget the most?

Trace Theories of Memory. Before the questions that have just been asked can be answered adequately it will be necessary to inspect the nature of memory and to ascertain the theories proposed to account for the temporal aspect of behavior.

In the seventeenth century, Descartes proposed a trace theory in terms of pores in the brain which were widened by the passage of 'animal spirits' (nerve impulses) passing through them after they had been stirred into action, presumably by stimulation of the sense organs. Habit formation was to be explained by the widening of these pores after they had been used repeatedly. William James, in 1890, followed the traditional trace theory and interpreted habit as the wearing of pathways through the brain. All trace theories, it was soon discovered, raised the problem of accounting for *revivals* of the traces whenever a recall process took place. Further yet, they raised the problem of how these traces are organized in the brain so

that several of them, having to do with a series of related experiences, would properly function together.

The Synapse Theory of Traces. The modern theory of traces is the 'resistance-at-the-synapse' theory, popularly adopted as the physiological explanation of memory, habit and learning. Synapses are supposed, according to this theory, to offer resistance to the passage of impulses, because of membranes with which the tiny fibers of the axons and dendrites terminate, making a gap in the continuity of the nerve tract. This resistance, it was assumed, lessened as nerve impulses continued to pass over the juncture. Since experiences are obviously dependent upon nerve impulses it seemed logical to suppose that a repeated experience was represented somehow by this reduced resistance. Thus, reduced resistance became a 'trace.'

Fallacies of the Trace Theory. Since the trace theory is the last 'stronghold' of mechanistic thinking in psychology its difficulties must be inspected. Its fallacies hang together with all the others that have so far been considered. The motive for them all is the view that both the brain and the 'mind' are the products of originally independent parts, somehow *put together* into an object like a machine.

First, the 'resistance-at-the-synapse' theory meets up against the all-or-none-law, already studied. This law makes a trace at the synapse meaningless, physiologically.

Lack of Correlation Between Structure and Function. Second, the trace theory assumes that in the organism there is a strict correlation between structure and function. The numerous experiments performed by Lashley, Coghill, Child, Tracy, Bartley, Newman, Perkins and others prove the contrary. The facts against localization of function presented in Chapters III and IV mean that there is no possibility of predicting from structure to function. A given area or particle of brain matter does not play its part in the economy of the organism's behavior in accordance with an inherent structure because it has no inherent structure. Its structure and function, alike, are *derived* from the dynamic field in which it functions. Bartley, Newman, and Perkins [1] have shown by action current technique

[1] *Op. cit.*

that given parts of the cortex, in dogs, have more than one function. This fact was apparent also from Lashley's experiments.[2] The brain, therefore, is not a mass of structures each having its own particular and independent function. In face of these facts the trace theory is inconceivable.

Inefficacy of Repetition of Response. Third, the trace theory makes the assumption that habits are formed by repetition of response. However contrary to common sense it may sound, the truth of the matter is that habits are not made easier by a simplification process as would follow from a trace theory. A learned act is easier to perform than an unlearned act because a higher order of organization has *evolved. The learned act is not more complex from one standpoint than the unlearned. It is simpler, both in amount of energy expended and in distance covered by the movements that are made. But from another standpoint it is more complex. Not fewer, but more, synapses are involved, and the type of organization is more intricate. The differentials of potential in the brain are more numerous and delicate. Ease does not depend upon simplification, as ordinarily understood, but upon complexity, in the sense of greater differentiation of movement-patterns.* Recall Snoddy's experiment. Study Fig. 32 again and note that the original path was far more complex than the last one. The more highly differentiated behavior-patterns permit more direct movements of the body toward objectives or positions in one's environment. Habits, after all, are exactly the opposite types of activities from what the 'lowered-resistance-at-the-synapse' theory supposes them to be.

Dependence of All Experiences upon Stimulus-Patterns. Fourth, the trace theory makes the mistake of assuming that an experience hinges, alone, upon an occurrence in the brain. We know that personality will not exist in the absence of a human nature-pattern around it; that maturation is maintained only through constant stimulation. Likewise, *a given experience is not represented by a brain-pattern except when the stimulus-situation is keeping the pattern set up. The instant the stimulus is removed the brain-pattern disappears.*

[2] Lashley, K. S., *Brain Mechanisms and Intelligence.* University of Chicago Press, 1929.

A memory, a thought, any particular experience whatever, is a temporary adjustment of the organism to the particular stimulus-pattern that is acting upon it. Temporary adjustments find no representation in the structure of the brain; they need none in order to *occur;* they need none in order to *recur.* All that is needed is a general physiological condition in the brain, a general level of maturation or differentiation of the system, accounting for insight, general speed of reaction, and refinement of co-ordination. This system is capable of being formed into functioning patterns of a given degree of intricacy while the stimulus-forces last that form the patterns. Since the patterns are formed each time the stimulus is presented, different parts of the brain are doing different things under varying stimulus-conditions.

An Analogy. Consider the air in a room, and assume, to begin with, that there are no currents. Light a candle and a current of air will be set up. Introduce more candles and the air will be chopped into many currents all of which must adjust to each other. Now blow out the candles. The currents disappear. The brain is like the air and the candles are like stimuli. Remove the organism from stimuli and an analogous process takes place. There are no traces left in the atmosphere. There are none left in the brain, for the brain, in principle, is a fluid field of energy like the air. In one case the air is necessary for air currents; in the other case brain substance is necessary for brain currents, but in neither case are traces involved.

Modern Conceptions of Memory

Köhler's *Dynamic* Theory of 'Traces.' One of the latest theories of memory has been proposed by Köhler [3] who suggests, first, that when any external stimulus impinges upon the nervous system, the existing state of the system changes until it is in equilibrium with the force acting on the sense organ. If, however, another stimulus affects some other part of the organism before the first equilibrium has been reached, the first approach to equilibrium will be altered by the change

[3] Köhler, W., "Zur Theorie des Sukzessivvergleichs und der Zeitfehler." *Psy. Forsch.,* 1923, Vol. 4, 115-175.

going on toward equilibrium with the second stimulus. This means that the two approaches to equilibrium will cut across one another; they will be interdependent, for stresses are 'fluid' in character, and cannot exist in the same field without adjusting to one another. Second, this theory supposes that the change toward equilibrium continues after the stimulus is removed. The stimulus alters unevenly the potentials in the brain, but their return to equilibrium takes time, because the membranes between cells offer resistance to the equilibratory process. The original disequilibration will for a time determine in part the trend of the changes set up by subsequent stimuli since the effect of the latter is influenced by the field of stresses upon which the effect must be felt. For reasons that need not concern us here, it is convenient to think of the mutual adjustments of the two disequilibrations to each other as a 'non-process condition.' The 'non-process condition' is the substitute which Köhler offers for the older conceptions of the memory trace. When an old 'non-process trace' comes in contact with a new 'trace,' the two affect each other in such a way that a new mental process results. In this way, Köhler accounts for errors of memory as well as for imagination and daydreams, or in other words, for the aspects of mental life that do not resemble past experience.

An Extension of the 'Non-Process' Theory: Chladni's Plate. Suppose that a horizontal metal plate of some sort (Fig. 46) is fastened, on one edge, to an upright bar. The surface of this plate is covered evenly with a layer of sand. If, now, this plate is made to vibrate at a constant rate the vibrations will keep the sand equally distributed over the plate. But suppose that while the plate is still vibrating it is suddenly bowed with a violin bow on one of the free sides, at A. The bowing momentarily induces added vibrations which must adjust themselves to the other vibrations already going on. *The sand will now arrange itself into four equal areas, with two streaks which contain no sand bisecting the square plate into four equal parts.* The original force applied to the plate continues to keep it vibrating at the steady rate set up before the bowing, so that when the bowing stops the sand will gradually approach the equally distributed condition existing at the outset.

This illustration helps us to understand the condition which exists in the brain under Köhler's theory of disequilibration.

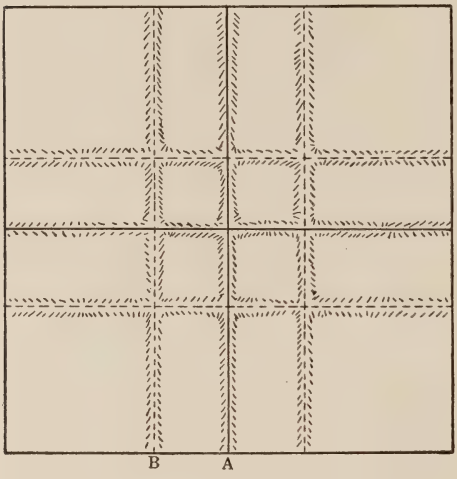

FIG. 46. CHLADNI'S PLATE.

The heavy lines indicate the lanes in the sand when the plate is bowed at A. The dashed lines indicate the lanes in the sand when the plate is bowed at B. Notice that if the plate is bowed at both places at the same time, or one immediately after the other, there are 16 divisions instead of the total of 13 that would be made, in all, if the points were bowed separately.

The original, equally distributed condition of the sand represents the original equilibrium of forces within the nervous system. The constant vibration represents the dynamic character of the condition. The bowing corresponds to the impinging of some external stimulus-pattern upon the system. In the case of the plate the bowing sets up stress-patterns of four equal areas as indicated by the distribution of sand. There has been a mutual adjustment of two stresses, one set up by the first vibratory force, and the other by the bowing. The consequence was a 'non-process condition' set up in the sand. This was the pattern formed into the four square areas. When the bowing stopped, however, the four sections began to disappear. The sand began at once to approach the condition of equilibrium again, and this was the equal distribution conditioned by the original vibrations. The return to the original equilibrium took time.

The picture must now be complicated. To return to the plate, suppose that the plate is bowed at *B, shortly after it is bowed at A.* The second bowing would ordinarily divide the sand on the plate into *nine* equal areas, but it is already divided into four equal areas which have started to disappear. *Upon the second bowing the sand will divide into sixteen areas, some of which are more sharply defined than others.* In terms

of Köhler's theory this second bowing corresponds to the second stimulation, introduced before the first brain disequilibration has returned to normal.

Notice that when the plate was bowed at A four areas were produced. If the plate had been bowed only at B, nine areas would have been produced, but when the 'B-stimulation' was introduced before the effect of the 'A-stimulation' had subsided, the 'B-stimulation' resulted in sixteen areas. Two disturbances or disequilibrations, each produced by a separate 'stimulus,' underwent mutual adjustments of their own, *producing an effect that neither 'stimulus-pattern' itself could have produced.* The brain, like the field of sand, is 'fluid.' It must respond to external stimuli in general in much the same way. The brain reaction at any one time is never what it would have been if the stimulus had produced an effect independent of a previous disturbance. We can see from the plate-illustration how at no time is there a one to one correspondence between 'stimulus' and 'response.' The sand is making a 'configurational' response to a total 'stimulus-pattern,' not a summation of the two 'responses' that would have been made separately if the two 'stimuli' had produced independent effects.

Limitations of the Dynamic Trace Theory. We are now in a position to reconsider the 'non-process' theory. Suppose that, for an instant, the plate was bowed again, and perhaps a fourth time. The sand will become divided into so many parts that they would be indistinguishable from the equally distributed condition at the outset. It is obvious, however, that the picture, here, is a simpler one compared with what would occur in the memory process when the individual is constantly responding to *different* stimuli. Nevertheless, if the two principles are the same, as they obviously are from a general dynamic standpoint, 'memory traces' cannot be explained in this way. The brain is constantly being stimulated, so that the 'traces' would be constantly changing toward finer and finer differentiations of pattern until, shortly, there would be a homogeneous condition in the brain and therefore no 'traces.' In fact, Köhler's conception is not a *trace* theory because the condition of the stresses depends upon the stimulus-pattern and its rate of repetition. Remove the stimulus and the 'traces' all

disappear. After all, therefore, the 'traces' cannot account for memory but only for the experiences which stimulus-patterns, as such, induce. The 'non-process' theory is a theory of experiences having exclusively to do with the present.

Perkins' Experiment. Recent experiments have brought to light facts which point in the direction of an extended dynamic theory of memory. Following Wulf's [4] general procedure Perkins [5] presented 150 naïve observers with two sets of five simple non-symmetrical, geometrical figures which were drawn with black ink on cards eleven by fourteen inches. One set of five cards was presented to one group of observers and the other set to the other group. The cards were exposed one at a time each for five seconds, until the entire series of five had been presented. This was the only time that the observer saw the figures. Twenty seconds after the series had been exposed the observers were given blank paper and instructed to reproduce the drawings that they had just seen, then on the 2nd, 3rd, 9th, 16th, 21st and 35th day after the original presentation. This meant that since the stimulus-figures were presented only once at the beginning, a series of reproductions was obtained that would indicate the undisturbed trend of the change in memory with successive increments of time.

The results from this experiment showed that out of the 3,559 reproductions of the ten stimulus-figures the most general change in recall was in the direction of a *simple, symmetrical pattern.* In fact only a few of the reproductions, those which were made early in the experiment, showed no changes of any kind. These changes fell into the following general groups: (1) Equalization of corresponding lines and angles within the figure; (2) orientation of the figure either to the horizontal or to the vertical plane; (3) a change toward standard objects or toward geometrical figures such as circles, ovals and squares; (4) simplification in the form of omissions, or a gradual decrease in some characteristic; (5) complication in the form of additions, or an increase in some characteristic;

[4] Wulf, F., "Beiträge zur Psychologie der Gestalt; VI. Ueber die Veränderung von Vorstellungen (Gedächnis und Gestalt)." *Psy. Forsch.,* 1922, Vol. 1, 333-373.

[5] Perkins, F. T., "Symmetry in Visual Recall." *Amer. J. Psy.,* 1932, Vol. 44, 473-490.

(6) completion either in an addition of a new part or an increase in an old one; (7) a change toward relations of proportion between parts; (8) changes of parts toward bilateral

Fig. 47. Changes Toward Symmetry in the Successive Recalls of Visual Figures (Perkins). By permission of the *Amer. J. Psy.*

symmetry; (9) a change toward symmetry of the total figure. (Fig. 47.)

When the average number of these changes for each reproduction of the figure was calculated, it was found that the greatest number occurred in the earlier recalls, the increase in changes becoming more gradual from then on. This indicates

that when there is a small time interval before recall there is a large number of small or minor changes. With a longer interval, the changes are not proportionally as great in amount, but are more significant because they altered the form of the figure more perceptibly. There was also indication that the change toward symmetry was more rapid over a long time interval when no reproductions were introduced, than if the same length of time was broken by reproductions. This shows that in the recall of memorial material the reproduction itself acts as added stimulation which cuts across the tendency toward a symmetrical pattern. (Fig. 48.)

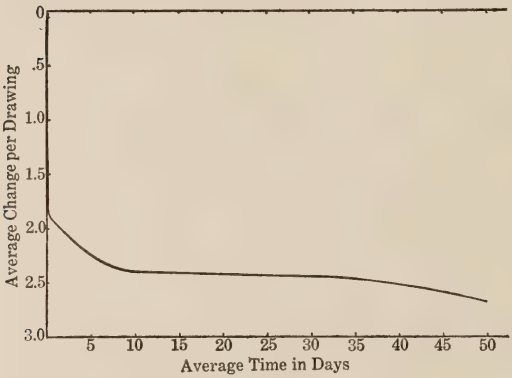

FIG. 48. CURVE SHOWING RATE OF CHANGE TOWARD SYMMETRY IN SUCCESSIVE RECALLS OF VISUAL FIGURES (Perkins). By permission of *Amer. J. Psy.*

One of the most important results of this experiment was the fact that the change toward symmetry was *progressive*. If a particular change occurred at the outset it was progressively exaggerated or diminished with each successive reproduction. As this progressive change continued it involved more and more of the entire figure, resulting in maximum or nearly maximum symmetry in the end.

Symmetry and the Law of Least Action: A Theory of Memory. The fact that in this investigation the trend toward symmetry was overwhelmingly the rule, points to a theory of memory. The change toward a symmetrical drawing or a stable, simple figure is a response in the line of least action. In order to understand why the reproduction of a symmetrical figure is a least action response, one must trace through the successive processes of recall. First, when the original material was presented, it set up a stress in the learner which was resolved in the *perception* of the drawing. At a subsequent time,

when recall was required, the instructions set up a tension which could only be resolved by drawing a figure. Second, there was a difference in stress between a high and a low, existing in the brain-field at the time of recall. Thus the stage is set for least action. In terms of the laws of dynamics the resolution of the high stress will take place over the most direct route in time, but what is the most direct procedure of recalling anything? It is to perceive, in imagination, as simple an object as possible. Try to recall a scene of your early childhood, say a wagon-ride on the farm. Try to describe the wagon which is the important thing in the picture. If you should take your description to a farm-implement store you would find that there is hardly a single distinguishing characteristic about the wagon that you described. It had taken on the simplest form possible, that of a general type wagon; it was any wagon, not a particular one!

Third, in the foregoing experiment the general figures were symmetrical, and the simplest that could be recalled under the existing conditions. Under the laws of dynamics, symmetrical figures require the least amount of energy to perceive; they are the most stable and easiest to reproduce.

Testimony. Additional evidence of memory as a least action response comes from a study of testimony. Suppose that a person is walking down the street; he suddenly looks up and sees two cars crashing at the corner. The cars are in a certain position, but the observer did not see the cars approaching one another. In telling the story subsequently, however, he will make a *coherent* story of it. Under the law of least action he will give it, if possible, *maximum logical form* or *pattern.* He has guessed, from talking with the drivers, that Jones was at fault, so, in the recall, Smith reached the intersection first and was driving slowly, while Jones was approaching at terrific speed and did not have the right of way. The story, now, is logical; one item follows from the other; it is simple, balanced, 'symmetrical' in a logical sense. The witness has not maliciously changed his story; the only way that the story could be remembered was to make it a coherent account; it was a least action response.

The Development of the Balanced Logical Pattern. The experiments of Wulf and Perkins demonstrated that the

symmetrical memory-pattern does not develop suddenly, but gradually and progressively. The distortion to which testimony or any form of ordinary recall is subject, is also gradual and progressive. Time is an important factor, therefore, in the memory process. If you are asked to recall an incident which occurred a few hours ago, you will find the task comparatively easy, and that a relatively large number of details can be remembered. If, however, you try to recall an event of several years ago, you will find that the task is difficult and that only a few of the details have survived. The second reproduction will exhibit a change toward 'symmetry' or coherence in logical pattern.

This fact can be explained as follows in terms of least action: The recaller possesses a field of brain energy of a certain definite amount. When the recall is difficult, more of this energy is expended in the *effort* to initiate the recall and less goes into a construction of the recalled object, the perceptual pattern. Under these conditions his energy, available for recall of the figure, is diminished, and as a result the simplicity of the pattern is enhanced. In immediate recall, however, a smaller amount of energy in his total brain-field is expended in initiating the recall, and more goes into the construction of the figure or recall, proper. The result is greater detail and accuracy.

The law of least action applies in still a different way. After a long interval has elapsed between the original observation and recall, there is only meager aid from external sources of stimulation that suggest the details of the recall. This is why the recall is difficult and requires more energy to initiate. Everybody recognizes this fact, at least implicitly. Did you ever leave your room for some other part of the house and forget, when you arrived there, what you went after; and then return to your room in order to remember what it was?

Initiation of Recall: Law of Configuration. The first important problem, dealing with the nature of memory, has been discussed, namely, the reason for the changes which it undergoes in time. The next problem is to ascertain how recalls are *initiated.* In order to understand how recall is possible by a human being who obeys only the laws of dynamics, bring to

mind the law of configuration. One is always responding to a total situation, and to every detail of the situation in relation to all the others. The story is often told of a horse that was being driven along a country road. At a certain place a newspaper blew across the road and the horse shied. About three weeks later it was being driven along the same road and when it came to this place it shied, but there was no newspaper. The original response of shying was not made to the newspaper, alone, but to the total situation, the fence, trees, and the bend in the road. There was enough of this situation left to produce the response a second time. In all probability the situation would have produced shying indefinitely had the horse been driven by the same place the requisite number of times, but the horse is capable of discovering, eventually, that after all, nothing remained in the situation of which to be afraid.

A certain person, when he was a young boy, learned to play from memory a march on the piano. A few years later he tried to recall the selection and succeeded except for a few measures which he was not able to figure out. For several years he tried to reconstruct this passage, but failed. Nearly ten years later he returned to his old home, sat down at the old piano and played the entire march with perfect ease. Professor Warren [6] relates the story of a remarkable recall of this kind. An elderly man returned to his *Alma Mater* to receive an honorary degree. Amid certain of the festivities of this occasion he excitedly arose and recalled *verbatim* the text of his freshman oration, about which he had not thought for a great many years. These cases bring out the same point as was illustrated a short time ago when the example was given of returning to one's room in order to recall a forgotten errand. The secret of recall is *sufficient duplication of the original stimulus-situation to permit a response partly resembling the original.* The original response is called perception and the recall a memory process, but there has been no revival of a past experience. There has been a construction of a response resembling, in part, the original, because the conditioning factors have been partly duplicated. In other words, recall is a partial perception; it is an attempt

[6] Warren, H. C., "Two Cases of Long Latent Memory." *Psy. Bull.*, 1918, Vol. 15, 207-209.

to perceive, over again, the original object, under the handicap that important stimuli are missing.

A Detailed Illustration. This theory may be illustrated in more detail by the following example. A person spends a summer in the mountains, camping. He is responding to a total situation: the mountains, lakes, woods, his automobile, camping equipment and his companions. But more than that, he is responding to *his own language.* While he is on his vacation he talks about the scenery, using such words as 'mountains,' 'lakes,' 'woods.' He responds to these words in the total situation. They become potential stimuli, therefore, for subsequent recalls of the trip. If a given recall takes place immediately after a return from the trip, the stimulus-pattern is comparatively similar to the original, and recall is fairly easy and detailed. The car still bears the scratches of hard mountain driving; the camping equipment is being stored away; friends are questioning the recaller about his trip; there are souvenirs around, pieces of rock, photographs, a pine cone. All of these act as stimuli, partly duplicating the original pattern. A year passes. To recall the vacation is now more difficult; many of the stimuli are out of sight. The automobile has been sold and a new one bought; the tent has been stored away; the pine cone has disappeared; the photographs are lost. People no longer ask him about his trip. There is little left now to initiate a memory except the recaller's own vocabulary. In proportion to the lack of detail of the stimulus-pattern the recall will simplify, become general and vague, under the law of least action. There has been no fading of a trace, but *there has been an elimination of stimuli.* Seen in the light of a conception of this sort, to posit a trace for a recall is as absurd as to posit a trace for the original perception, for the individual is not doing two different types of things when he observes and later recalls the observation. He is doing the same thing at both times, the first time more completely than the second.

Why should the horse, in the earlier example, shy the second time if the original experience had left no impression? *The reason why he shied the second time was exactly the same as the reason why he shied the first time!* A newspaper was blowing across the road and the horse was responding to the *total*

situation. The total stimulus-pattern induced the response, which was configurational in character. The same stimulus-pattern, or one similar to it, is going to produce the response again, for the same reason that it produced a response the first time, unless the horse discovers, meanwhile, that there is nothing to be afraid of. If a trace were necessary to account for the second response, one would also be required for the first! The shying both times was a matter of horse-insight.

Problem of Forgetting

Measurements of Forgetting: Ebbinghaus. The problem of memory naturally introduces the problem of forgetting. The process of forgetting was first subjected to laboratory control by Ebbinghaus,[7] in 1885, who employed both meaningless and meaningful material. He constructed several series of nonsense syllables, each of the twelve syllables written on separate cards. He presented the syllables to himself at a fairly rapid rate, allowing fifteen seconds at the end of the series. Then he exposed them again, repeating this procedure until he could reproduce the twelve syllables correctly. After nineteen minutes he relearned the series, recording the number of 'repetitions' now necessary for perfect recitation. Because the number of repetitions saved in the second experiment was a measure of 'retention' he called this the *saving method.*

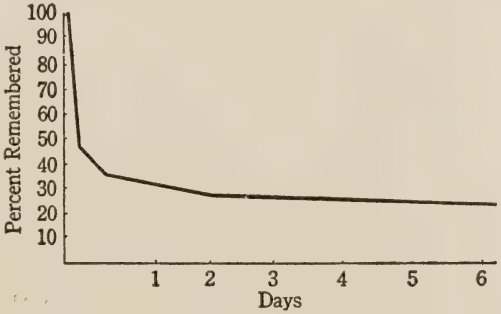

Fig. 49. Curve of Forgetting (Ebbinghaus).

Then he selected another series; learned it as before, and allowed sixty-five minutes to elapse before he relearned it. He relearned a third series at the end of eight hours, a fourth at the end of twenty-four hours, a fifth after

[7] Ebbinghaus, H., *Memory.* (Tr. Ruger.) New York: Teachers Coll Col. Uni. Press, 1913.

two days, a sixth after six days, and a seventh after thirty days. Plotting the percentage of saving in each instance he obtained his famous curve of forgetting, shown in Fig. 49. From this curve it can be seen that his forgetting proceeded very rapidly during the first twenty minutes. More than half of the material was forgotten during the first hour, then the rate of forgetting rapidly decreased. It is curious that the curve obtained by Perkins on the changes toward symmetry, with increased time intervals, is approximately of the same shape as this curve. It must mean that both curves picture the dynamics of an approach to a balanced and stable pattern of response, whether the material is composed of figures or of nonsense material.

Qualitative Aspects of Forgetting: Crosland. We have advanced the theory that recall is a response made in the absence of completely repeated stimulus-patterns. This view receives substantiation from a study by Crosland [8] on forgetting. He exposed different objects to his observers, such as a mannikin, colored and uncolored pictures and geometrical designs. Immediately after the presentations the observers were asked to tell what they could about the objects and describe in detail their mental processes at the time of the recall. Then they made recalls after longer and longer intervals of time and reported as before.

Crosland found that his observers, on the first presentation, assumed definite attitudes toward the exposed objects, and more important still, retained these attitudes during the subsequent recall. This means that the stimulus-patterns were similar enough to condition a general attitude toward the material in both perception and recall. The attitude was a field-property of both responses. The subjects also *resisted* forgetting; in each recall they were trying to inspect the object as if it were actually present. With the passage of time their memory of the material became more subject to error, and these errors were determined in large measure by the effort to resist forgetting.

A Theory of Forgetting. The results from this study, and from others of a like nature, show that the forgetting process is an active, not a passive, affair; as measured by recall *it is*

[8] Crosland, H. R., "A Qualitative Analysis of the Process of Forgetting." *Psy. Mon.*, 1921, Vol. 29, No. 130.

an effort to continue learning under adverse conditions. It is a process taking place in the absence of completely repeated stimulus-patterns, the completeness of which is one important condition of forgetting. There are certain aspects of this stimulus-pattern that are not under control in the forgetting process, which means that the trend of forgetting will differ from individual to individual and even in one individual from time to time. These uncontrolled conditions are his attitudes toward the object, his desire to recall as much as possible, his concept of what the object should be, and his desire for the object to take on certain characteristics.

That forgetting is an active learning process, taking place under the handicap of insufficient aid from stimulation, is substantiated by the fact that if the actual object is re-observed the perception of it becomes more accurate and comprehensive. The recall of the object is no different in principle than the re-observation of the original; the difference lies in degree, not in kind, and is conditioned by the adequacy of the stimulation. Perkins' experiment showed that the reproduction of the material acted as additional stimulation, so that forgetting did not proceed at so rapid a rate as if the reproduction had not occurred. In the recall of an absent object there is a constructive process which progresses toward a symmetrical or coherent reproduction of the material.

Errors of Recall. The work of Crosland, and others, shows that the resistance to forgetting reveals itself in numerous ways. First, of course, there are errors of omission common to every recall. Because the actual object is not present the observation at the time of recall is incomplete, but the incomplete response is possible since the actual object is only part of the original stimulus-pattern and other stimuli belonging to that pattern are repeated. Second, attempts to resist errors of omission result in errors of elaboration. The conditions under which these errors appear include such factors as eagerness to give an elaborate account either for the sake of boasting or for the sake of telling a good story. Stories told by other individuals about the same event, or events of a like nature, are influences which also affect recall; the social and emotional tone of the original situation for the observer emphasizes those facts

which harmonize best with his attitudes and purposes; the observer tends to recall past events as he thinks that they should have taken place. These conditions all operate in the specific direction of a balanced story.

Third, resistance to forgetting takes the form of *typifying* the object or event recalled. The object takes on a *class-value* for the observer. The illustration of the wagon-ride, given earlier, is a good example of this form of error. The wagon was remembered not as a particular wagon but as an 'average' wagon. The description of it, in the recall, was confined to the general features of wagons, the only way in which the event could have been remembered. So it happens, universally, that a memory of a simple event ultimately becomes general enough to represent any one of a number of previous experiences.

Fourth, verbal and motor experiences, because of their simplicity and homogeneity, are not subject to as many errors of recall as visual or other experiences which depend on the more specialized senses. For example, in the recall of a particular scene in the mountains, the colors of objects, the size of the flowers, the spatial position of the rocks, are soon forgotten unless language can be relied upon to supplement the visual imagery of the scene. The features of the scene that can be symbolized the easiest in words are remembered with the greatest accuracy. In fact, words, symbols and gestures finally dominate the recall process. They are the tools representing the easiest things to remember. The memory, now verbal, has taken on the same stable form as written language and number. Although the scene, just mentioned, was a very impressive experience, it is remembered from this time on, verbally, as a 'blue valley covered with flowers.' Yet, *it is still remembered as an impressive scene.* The significance and feeling value of the scene are the general, undifferentiated field properties, the last aspects of the experience to be forgotten. Undifferentiated wholes are first in the genesis of a given experience. They are last in the disappearance of the experience.

Practical Psychology of Study

The Problem of Learning to Study. Relevant to memory is the problem of how to study effectively, for effective study should mean ease of subsequent *recall,* and *use* of the material studied. Learning how to study should begin in the elementary schools. The problem commences therefore, with methods of *teaching the child.* This leads us to one of the most serious faults of our present educational system. Under present methods, there is altogether insufficient emphasis placed upon the conditions that promote efficient study. Who has not seen the child looking at his book while he is daydreaming, only to receive a report from him subsequently that he has been industriously at work? What teacher of a supervised study-room has not felt that forces of some kind were at work against the success of what would seem to be an improved method of classroom management? The subject matter does not 'take' as it should; there is an undercurrent, often of confusion and discontent; there is an inclination on the part of the pupils to take advantage of their freedom. Obviously, something must be wrong when this situation exists, for the child does not exhibit this type of behavior *when he first begins his school.* Many facts have been encountered in our discussion of the learning process, of motivation, and of personality, that explain why the child becomes bored with school, *and, as a consequence,* does not learn to study. These facts also point in the direction of certain remedies which will make possible a fulfillment of the aims of Education. That pupils who go through the primary grades and high schools do not, on the whole, know how to study, is indisputable. It is the commonest complaint of college Deans and Advisors, and of college Freshmen, themselves.

Importance of a Goal in Learning to Study. No pupil will learn how to study without the *will to learn* and without a definite goal. He can be given this will to learn only by making the task interesting and *necessary* for his happiness. The happiness that promotes learning is not the happiness from a bribe. Such joys are over when the grade is received! A geography lesson about South America, for example, may be in the nature of an imaginary trip that the child makes, but the scenes on the

way should be scenes that the child would see, not what an adult would see. When these conditions are fulfilled the child not only *wants* to learn, but *must;* he will spend extra time in solving problems and accumulating facts about geography, outside of the schoolroom. *He cannot understand that the study of geography will make him an intelligent citizen; but he can understand that foreign lands are populated by interesting people, living interesting lives, and having interesting ideas;* his geography can be a story that one reads for pleasure. The goal is definite, in this case, for it is *his own.* When the imposed goal is the abstract one of an adult, the child will not grasp it; instead, he sets up goals of his own, and if he cannot find them in the subject matter, which is usually the case, he will find them in daydreaming, getting by, or cheating the teacher. He should and could, if the chances were given him, pursue the task with the same enthusiasm that he learns football and baseball.

Pacing and Maturation. Spacing of work periods is important if the child is to learn how to study. The young child, especially, works for only a short time at a given task. This is because he is always resolving tensions toward goals of discovery. Children must explore and wander. To talk about a fluctuating 'attention' does not solve the problem. Children *abhor* monotony and drill. When, by the drill method, the same task is presented over and over, until the pupil finally learns it, he has learned in spite of, rather than because of, the method imposed upon him. Drill is resisted and resistance adds to over-stimulation. Maturation ceases and an irradiation pattern sets in. The pupil loses interest in the task and becomes fatigued, makes little progress and becomes discouraged.

Guides to High School and College Study: The Whole Method. The following rules are effective for adequate study methods. First, the task should be approached by the whole method. We have seen the advantages of this method as compared with the part method, which breaks the task into units, learned as such. Recall the illustration of a Civil War assignment in history. General readings about the problems of the war should come first. Then the particular chapters should be read *in toto without trying to memorize anything.* The general plan of the material should first be grasped. For this first

reading, names, dates, cities and so forth, are not important. The important things are the causes and consequences of the war, the masses of people involved, their attitudes, and in *general* how they conducted the war. This method furnishes the basis for the details, such as names, dates and localities. This first reading is an undifferentiated but necessary preliminary grasp of the whole problem; it is the whole from which the parts are to differentiate. The student may now read the chapters a second time and perhaps a third, and evaluate the various detailed events in the light of the whole. He will find that certain names are emphasized, such as Lincoln, Grant, Davis and Lee, and that certain battles are emphasized and that certain localities appear important. If these items are not comprehensible in the light of some whole, the pupil has no business studying history. It is a waste of time. The usual procedure of requiring the memorization of dates, names, places and chronologies is not teaching history. Learning them is not learning history. These items mean nothing except as parts of the story which gives to them their significance. Lincoln, for example, is not important unless seen in light of the total situation in which he figures, namely, the slavery question, and the importance of National Unity. Davis is not important unless seen in light of the States' Rights problem. When this method is adequately followed there is no necessity for memorization. Anything that would have to be memorized would not be worth memorizing. Remember that logical memory does not involve memorizing.

Budgeting of Work and Recess Periods. Second, the student should at all times distribute his work and 'recess' periods. It is the individual student's task to discover for himself how long he can study given kinds of material without forming an irradiation pattern. Until he discovers for himself his maximum length of work period, it is better to work for a shorter period and then rest, than to work too long. *The student's time should be budgeted,* and the work on one assignment distributed. The following plan is effective for a two-hour allotment devoted to a given assignment of reading matter due the next day. First rapid reading ½ or ¾ hour in the afternoon; second reading 1 or 1¼ hour at night; third reading

½ or ¼ hour next morning. The trouble is that most students will not go to the labor of *planning* their time; they do not appreciate the immense value of distributed study.

Various Kinds of Recitation. Third, recitation, oral or 'written,' should be introduced into the process of study after an assignment has been read over. This will help the student to see the larger and important aspects of the lesson. The larger, gross aspects *are to determine the meaning* of the finer details and are therefore very important. Recitation, as a study method, is more effective than 'repetition.' In case of the history lesson, for instance, the student should *stop* and *consider* the important general problems of the Civil War period, in the form of a *recitation.* The most effective form is to *discuss* with a companion who is also taking the course. Telling a story to another person or discussing it with him necessitates an understanding of major issues and a subordination of detailed facts to them. As the course develops, these recitations should be introduced as often as possible. No better way to achieve coherency of form can be found than to engage in an argument, or group discussion, about the facts and their relative merit.

Group Discussion. Fourth, group discussions are excellent methods of study, both in college and in high school. Care should be taken, however, not to make rivalry the important factor in the situation. When rivalry is emphasized it is likely to lead to memorization. The only legitimate place for this motive is where the rivalry comes in outwitting the other fellow in debate. It should be employed in the spirit of sportsmanship, where there is satisfaction even in defeat. A study period may be devoted to this procedure. A history lesson may be attacked, eventually, in the form of a group 'free for all,' or in the form of impersonating the characters, where each student must defend his position. This is the real creative way to study. Its virtue lies in the fact that not only does it promote a deeper understanding of the material, but, *creative thinking afterwards.* The student will return to his room and, socially motivated, expand upon the suggestions obtained from others. Frequently, creative work is best done alone, but it must have prior social stimulation.

Outlines. Fifth, properly prepared outlines and skeleton notes are very useful. They remind the student of the essentials of the lesson, or in other words, the coherent plan or form of the material. When the student reviews such an outline he is following the same order as that in which he learned the material. He reviews the gross plan and the details follow, in memory, in their correct order and relationships. When the student recites with this plan in mind he is able to give a satisfactory account of the subject matter.

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CHAPTER XXII

MOTIVATION

The Problem of Motivation: Educational Applications

Status of the Problem. No problem in child development, or in the control of the learning process, is more vital than motivation, and more in the need, at the present time, of careful investigation and analysis. Nowhere in the field of human management are the teachings of conventional psychology more fatal, if logically and consistently carried out, for they are intrinsically mechanistic and false. An adequate education that will fit youth for a control of himself, and will fit the rising generation as a mass for a mastery of social, economic and political problems, all the way from those of his community to those of the world of humanity at large, depends upon a deeper and more accurate insight into the laws of human nature than psychology has previously given it.

We are not training our youth in ways that would make impossible entrance upon careers of crime; we are not teaching them to respect the resources either of their natural environment or of their intellectual, artistic and moral selves; we are not giving them foresight, or a basic idea of human culture, or a conception of the goal toward which the race is laboriously and painfully striving. As a consequence, youth does not learn what human life in its deeper aspects is all about, or what the social, political and moral problems of the day are like. Not knowing, they cannot assume leadership in a solution of these problems; not caring, for they are not taught to care, they have no desire to try, or a sense of the problems that are demanding solution. Accordingly, the general cry throughout secondary and higher education is that students are intellectually and morally lethargic. How can they be otherwise? They lack motivation.

The Nature of Motivation. There is no one definition of motivation because there is no one kind of motivation. First, a motive may be regarded as a reason for doing something. Dynamically it is a tension that demands resolution toward a goal. In this sense it is synonymous with the dynamic aspects of behavior itself: will, emotion, purpose. Second, it is fruitful to consider motivation as *the process of inducing motives.* Then it is a method of energizing behavior. There are in general two methods of motivation, both of which depend upon a control of stimulus-patterns. Through a control of stimulus-patterns the organism is energized into greater action by *raising* its potential energies.

Internal Stimulation. The first of these methods consists in the control of internal stimulation. This control is effected by selecting those environmental situations that lead to internal stimulation; or, it may be effected by timing the selection of the environmental situations to coincide with the periodic stimulation that comes from within the organism. For example, the most common method of motivation in animal experimentation is to deprive the animal of food and to employ food as an incentive. Other methods are to confront the organism with situations that quicken its general physiological processes through the inciting of glandular secretions and a redistributing of its bodily energy. Examples of these are the arousal of fear, anger, jealousy and rivalry.

The Appeal to Pre-existing Desires. The second procedure controls external stimulation in such a way that the pre-existing desires and goal-activities of the organism, less directly concerned with its physical needs, are given freer expression. This is done by taking advantage of play and recreational motives, social approval or disapproval, and social standing, or, by appealing to moral values and ideals. Social motivation, as has already been indicated, is important, but requires careful control. It may be applied effectively, but it is difficult to energize a human learner through most of the social methods without creating undesirable goals. Safer procedures, belonging to this second class, are those which appeal directly to the individual's curiosities, desire to learn, spirit of discovery and adventure, interest in the new, and natural creativeness. *The*

principle in these two general forms of motivation is that of providing a goal and making it attractive.

Reduction of Problem to Learner's Level of Insight. Third, there are two methods of motivation by reducing a given learning problem to the learner's level of insight. Of all motivating procedures these are the best, and ideally the only necessary or even legitimate methods. One of these is the reduction of a problem to the learner's level of insight by punishment, but this, wherever possible, should be avoided. In certain situations it is necessary. The other, and by far the better technique, is to reduce the complexity of the task, if it is beyond the learner's level of insight, and to raise it, if it is too far below his level. The one procedure is often as badly needed as the other in educational situations. This technique takes advantage of the *pacing* principle.

Fourth, there is an important form of motivation guaranteed solely by the personality of the teacher. She inspires or kills the interest of the child by her methods of handling him and the classroom as a whole.

Internal Stimulation Illustrated: Fear. Motivation by internal stimulation is seldom pertinent in the case of human beings who are learning temporary tasks, although, of course, human beings are always going through some learning process or other, to the end of providing food, shelter, and security for themselves and their families. While in animal investigations it is frequently necessary, no one would think of making a child hungry in order to encourage learning, except, perhaps, where a child is sent to bed without his supper for being unusually recalcitrant. Then, generally, there are better ways.

The internal stimulation method has been employed, recently, in the study of 'conditioned reflexes' or 'conditioned responses,' not of course in view of making practical application of the procedure to learning situations, but in an effort to ascertain how the emotional life develops. Fear, if induced in the right spirit and in the right situations, is an effective and legitimate method of motivation, as for example, where children insist on playing in the street, or wading into dangerous water, or playing near places where they might fall, or in play-

ing with dangerous objects such as knives. *Here the motivation should not take the course of making the child fear the disciplinarian but the actual situation itself.* The one who is doing the instructing may, himself, *feign* fear. To illustrate, a child may be living in a section of the country infested with poisonous snakes. Since he has no inborn fear of them it must be taught him for his protection. He may be too young to understand fear in the abstract, or to understand, thoroughly enough, a verbal warning. Let someone upon whom the child has learned to depend take an actual snake, and act out the fear of touching it. Should a young child insist upon playing with jack-knives the same procedure might be adopted, and in this situation, it would not be unreasonable, if the child's desire persisted, to scratch oneself aseptically, apparently with great pain, or the child himself if not done in the attitude of punishment.

It should be remembered, of course, that making use of these energizing methods is not alone a matter of producing internal stimulation. They are valueless without insight on the part of the learner, and must be carried out in a way that makes the learning as intelligible as it is emotionally intense.

Illustrations of External Stimulation: Social Factors. Examples of this type of motivation are found in learning through games, socialized recitation, and competing for record achievements. Geography is learned by groups of children fitting map-puzzles together, jig-saw puzzles of animals and birds in their natural environment, of family life of other races in their environment. Or, a class is taken on an excursion into the country. This is at the present time being done on a relatively large scale, especially in Germany, and interestingly enough, not altogether without a demand for it on the part of the pupils themselves. Another method is to 'dress up' like children of other races and to dramatize their manner of living.

Motivation Through Personality Contacts. Motivation through personality contacts between the teacher and the child is one of the most vital forms of all and, unfortunately in many cases, the hardest to achieve. Teachers range in personality all the way from good to bad, and regardless of their

type they profoundly affect the willingness of the child to learn; affect, indeed, the mental hygiene of the child for better or for worse.

Personality characteristics of the teacher determine whether or not the child will suffer a diminishing, if not a serious, loss, of his desire to investigate and acquire. Remember that learning is investigation and acquisition of the new; there is no other kind. What are these traits of personality? First, the teacher must exhibit an enthusiasm for everything related to her task, for the lives and interests of the pupils and for the subject matter which she teaches. Second, she must show generosity, expressed in a willingness to spend extra time with her pupils when it is needed; in an open-mindedness toward facts, especially when they deal with the lives and interests of others. Third, she must be well-balanced in her own attitudes toward life, as shown in a sympathetic respect for the child's personal problems and confidences; she must be temperate in her mannerisms, tone of voice, side remarks, and especially in her disciplinary measures. The unbalanced personality reveals itself in every posture, attitude, gesture, and utterance; the personality never has a 'poker face,' and children are quick to read the signs. Fourth, there is a long list of intangible qualities which control the atmosphere of the classroom: freshness; 'warmth'; 'charm'; happiness of disposition; dignity; sense of humor; aggressiveness of manner; kindness; keenness of insight into the personalities she deals with; straightforwardness; self-control, especially when anything goes wrong; grace; ease, especially in the presence of visitors; honesty in personal relations; conscientiousness, and cleanliness. Even the teacher's manner of dress is important!

Motivation Through an Appeal to Creativeness. Here are to be found the more recent emphases upon the project method where the child is given a simple problem to solve, preferably one of his own suggestion. This is effective either as an individual or a social project. A socialized project is illustrated by having a group of boys construct a locomotive, even if it is only out of odds and ends of boxes, broken chairs and tin cans.

One day a young boy asked his teacher if earthworms really

"rained down from the sky." "Do you believe it?" was the question the wise teacher asked in an *excited* tone of voice. The boy's eyes bulged as he said, "Why, I don't know whether to believe it or not." "How would you find out whether they do?" continued the teacher. Then, not by telling, but by asking questions, the teacher led the boy to see that finding earthworms on the sidewalk after a rain was not proof that they rained from the sky, and that it might be a good test, during the next hard rain, to hang a pail from the middle of the clothesline. The boy did it.

This story illustrates more than one aspect of motivation. First, the teacher was enthusiastic about the problem; she did not laugh at the boy for what might easily have been regarded as stupidity; she shared the boy's curiosity, an attitude on her part as important as the project method itself. Second, she did not *tell* the facts leading up to the method; *she made the boy think.* Third, she permitted the boy's curiosity to find satisfaction through the same channel by means of which the curiosity itself had come into existence, the boy's own inventiveness of disposition; she encouraged the boy to learn in the course of *doing,* which is the only way he really learns anything. Fourth, she did not permit the incident to drop; she followed up the boy's interest in facts about earthworms by referring back to the incident, by suggesting further projects and by asking him further questions.

Illustrations of Motivation Through Reduction of Problem to Learner's Insight. (a) *Punishment. The value of punishment in young children is that of reducing the problem to their level of insight.* For example, a young child is caught playing in the street. It is known that his perception of moving objects has not differentiated to the extent that he can judge speed. To perceive swiftly moving objects, adequately, requires a differentiated space-time world. It is dangerous for children to be in the street because they cannot tell when an approaching automobile, even if seen, would strike them; hence they will not seek safety at the right moment. If the child cannot be prevented from playing in the street by methods that keep him elsewhere until he maturates to the point where he can judge distances and speeds, there is no other alternative but to

punish him. But this must be done while the child is in the street, or about to enter it, for, in accordance with the law of configuration, he must perceive the punishment in relation to the situation or it will have no meaning.

Recall Köhler's experiment with the apes. When the ape saw a stick at the same time he saw the banana he could perceive the stick as a tool with which to 'fetch' the banana, but when the stick was at the opposite side of the cage and his back was turned to the banana while he looked at the stick, the latter was no longer a tool. The conditions for a configurational response at the ape's level of insight were not satisfied in this case. Accordingly it would be useless to punish the child sometime after he returned from the street or before he thought of playing there. A punishment in the street is the surest method. A sharp slap that hurts (not executed in anger) reduces the problem to the child's level of insight because he can understand pain, and that going into the street means pain. The child will keep away, not in order to protect himself from being run over, for that problem is yet unintelligible to him, but in order not to be slapped. Shortly the child will decide for himself that going into the street is a foolish procedure because it brings pain.

(b) *Appeal to Crisis.* Lashley[1] has recently performed an interesting experiment showing how taking advantage of a 'biological need' elicits evidence of more highly elaborate responses on the part of the rat, than if 'indifferent' situations are presented it. His method forced the animal to *jump* from a pedestal across an intervening space to two alternative doorways, with the reward just beyond. The doorways were both closed but the correct door opened freely when the rat jumped against it; the wrong door failed to open and compelled the animal to fall some distance to a canvas floor. Previously, rats had been required merely to walk or run to their goal; they had not been confronted with what might be called a 'crisis' which would stimulate their maximum insight. In fact it was not believed that the rat had the acuity of vision to permit so complicated a response!

One of the most common sources of failure in encouraging

[1] Lashley, K. S., "The Mechanism of Vision." *J. Genet. Psy.*, 1930, Vol. 37, 453-460; 461-480; 481-484.

children to learn in schoolroom situations is the fact that the task which confronts them is not sufficiently vital. Under the law of least action, *when a task is too simple for them, they will not respond with their ultimate effort or interest, or with their ultimate intelligence, for the situation does not demand it, and maximum responses never occur unless demanded.* In the chemistry laboratory, for example, the high school student may be given an experiment that, unknown to him, involves a sudden surprise, such as a harmless explosion or a sudden effervescence of a chemical substance. The clever instructor in physics will plan a crash as a consequence of a sudden release of forces. He will provide an electric shock. The novel, the surprising, anything that arouses awe, appeals. An explanation that brings out the reality of great magnitudes and distances, striking unsolved problems, the paradoxical, the power of overwhelming forces, are situations which always promote interest, curiosity and the desire to participate in investigation. In biology many appeals of this sort are available. These situations bring the goal nearer the learner, by an appeal to the law of increasing energy. The exciting, dangerous, awe-inspiring, and sudden, relate to conditions which threaten the integrity of the organism, or seem to threaten it. Nearness to this goal is simulated, with the resulting greater amount of kinetic energy on the part of the learner. More kinetic energy means greater achievement, taking the form of greater insight and a quicker grasp of a larger number of facts. It means greater imagination, also, for the energy thus raised to higher potentials takes form, always, in the highest types of mental activity.

(c) *Motivation by Pacing.* Sometimes failure to progress in school is traceable to the fact that the work is too easy for the child. The tasks required of him do not measure up to his level of maturation, or keep pace with it. In this case extra work should be given. In giving extra work the expedient should first be tried of enriching and varying the details of learning problems of a difficulty *at present* fitting the child's level of insight. Additional projects, to be carried out under the child's own initiative, are the most effective. The reason for this procedure lies in the danger of stimulating maturation too rapidly and of producing an over-precocious individual.

The problem of precocity is sufficiently serious to justify a special section to follow.

Failures to learn are also traceable to the opposite situation, that of making demands beyond the child's level of maturation. Many a child is pushed on into a higher grade before he is ready, for no reason than a misguided sympathy or an unwillingness to face conflict with an irate parent. Nothing is more pathetic than a situation in which dull children are struggling to keep pace with the class. Inevitable social complications arise; pupils laugh at 'dumbness'; the progress of the class is delayed; the teacher is forced to spend more than the time she should on the inferior pupils to the resentment of the superior ones; the superior pupils learn 'habits' of laziness, and develop attitudes of indolence. It follows, therefore, that special classes for the problem child are imperative for successful educational methods.

Precocity. There are two sides to the problem of precocity. The child who, very young, shows extraordinary creative ability must be allowed to express himself, but the temptation usually is to develop a misguided pride in his achievements and to encourage too rapid a development. He is spoiled by being 'shown off' and publicly compared with others less brilliant. He is over-stimulated when his nervous system is already hyper-sensitive to stimulation. Adult standards of living are imposed upon him and he loses the years of recreation and play necessary for the gradual establishing of stable action-patterns which will withstand the stresses of later years. He is pushed along into classes where the majority of pupils are much older, larger, socially and physically more mature, and where the chances are that he will not be socially acceptable.

There is a richness of experience, a repertoire of common sense judgments, and a stability of behavior, that come only with years of growth regardless of the level of difficulty of intellectual and artistic problems which the person can solve. Too rapid a development may deprive the individual of these important assets. The consequences are undue sensitivity in social relations, lack of social insight, hyper-emotionality, a helplessness because of no interest in practical problems, and perhaps, in the end, a breakdown and regression to infantile

attitudes. Children that are pushed too rapidly often decline in ability when they reach the adolescent period. They have been 'burned out.'

If possible, the precocious child should receive the stimulation he demands from an enrichment and variation of his tasks that will slow down the processes of maturation. However, if the precocity should be shown along some special line, as in music, where his creativeness can be fostered without making him a premature adult in all of his intellectual behavior, there is less opportunity for trouble. In such cases every precaution should be taken to preserve a normal child-culture such as play, naïveté, desire for companionship with children of like physical age, carefreeness, and enjoyment of all childish things.

Rewarding for Relative Achievement. The mistake is made, all the way from the kindergarten to the university, of rewarding the precocious individual in various ways for his superiority over others. This is disastrous to his modesty and leads often to the belief on his part that he knows much more than he actually does. He is praised for having achieved so much, when the standard of comparison is the achievement of the average. This not only leads to superiority complexes, when they are inexcusable, but sometimes fails to keep the superior student working at his level of efficiency. He acquires the idea that he need not exert himself, and develops a disrespect for the value of doing as well as he can.

Merit should always be given on the basis of *relative achievement.* The student who is naturally slow and expends his energy to the utmost may do poor work as far as the average of the class is concerned, but relative to his level of insight, his achievement is at a maximum. He should be recognized for his effort, his interest, and for using all that he has, a situation which our formal methods of evaluating student worth do not meet. The slow learner will do better work and sometimes will become superior if he is appreciated for his efforts and given the confidence of the instructor that he can do still better. The superior student whose achievement is below his own standard should not be rewarded for the absolute superiority of his work but on the basis of having, or not having, exercised his insight to a maximum. He may have been given an *A* or a 'Superior'

for a grade when, in proportion to what he could have done, he deserved only a *C* or 'Average.' Any procedure that encourages him to work at a level lower than his maximum is detrimental to his future. Like the precocious child, he should be given more work to do and evaluated for having accomplished in proportion to his ability.

The General Dynamics of Motivation

The Conditions of Motivation. Within fairly wide limits mental development and learning occur faster and with greater efficiency when the organism is behaving under increased tension. First, learning is hastened by motivation because intensified responses are faster; more of them occur in given units of time. Keown, in the Kansas Laboratory, found that energizing rats with thyroid secretion resulted in maze learning that was considerably faster and was perfected with fewer errors than in the case of normal subjects. His procedure may be called a physiological type of motivation, one that is not, however, to be recommended for human beings unless there is a deficiency of thyroid secretion (diagnosed by a physician), otherwise the physiological balance of the system-as-a-whole is seriously affected.

In human learning, movements and thought processes, alike, occur with greater speed, under the greater tension of interest in the task, under competition, anticipation of success, satisfaction at realizing one's previous progress, desire to please someone, and the thrill of doing something creative. Here, in terms of dynamics, increased tension goes over into greater momentum. Under these conditions difficulties are overridden more easily, distractions are unnoticed, and greater persistence is shown when conditions bring about delays in progress. In short, motivation increases the learner's kinetic energy, and therefore his achievement, by bringing the goal dynamically nearer to him or him dynamically nearer to the goal. One way of describing it is as correct as the other.

Second, motivation increases the learner's insight into the task. It actually raises his level of intelligence at the time. The same increase of stimulation that produces more rapid re-

sponses induces faster maturation, or differentiation of potentials in the nervous system. Increased differentiation means, in terms of dynamics, higher types of organization. In fact, quick and frequent responses can occur only under conditions of greater differentiation. This explains why, other things being equal, the rapid learner is the more efficient and why speed correlates so well with 'intelligence.'

Dangers of Motivation. On the other hand, motivation has its dangers. First, it will not produce more rapid learning and better insight when used to excess. In emotional situations that are too intense, irradiation sets in. Motivation then suffers in accordance with the law of diminishing returns. Emotional irradiation is the spreading of stimulus-effects relatively equally to all parts of the organism, producing a paralysis. Stage fright, being 'frozen stiff' at the wheel in an automobile collision, being 'impotent' with anger or rage, and 'stunned' with grief, are examples of this paralysis. Every muscle of the body is contracted so that no movements can be made. From the standpoint of the subject's experiences irradiation produces confusion, scattering of one's thoughts, and the condition described as a mental blank. Too much urging of a child will eventually lead to a situation in his behavior approximating such paralyses as these. He grows stale, loses interest in his work, becomes unco-ordinated, perhaps exhausted, and falls victim to a nervous breakdown. We have already mentioned this as a dangerous outcome of precocity. A large percentage of precocious children, stimulated too much over a period of years, become erratic and ungovernable, may stop maturing altogether, become maladjusted personalities, and permanently weakened in health. All this is the picture of a midpoint between normal, temperate motivation and the momentary paralysis just mentioned.

Futility of Ulterior Goals. *Second, unless motivation is relevant to the task, it results in the establishing of ulterior goals and defeats its own end.* Nature does not require of the apple that it fall to the ground (toward the center of the earth) in order to reach other points. By the same logic the remote end of mental development is knowledge that gratifies the desire for knowledge; the end of learning is a perfect perform-

ance of some kind, a language acquired, a musical instrument mastered, a game well played, a personality well balanced, an ideal reached. It is not 'some other point' like a star, a grade, a momentary reward, a piece of candy. It is natural, of course, that certain goals become subordinate to others, but the subordinate goals should be related logically to the main goal and should be emotionally congruous with it, something that increases insight into the goal itself and a greater appreciation of its value.

Primary Source of Motivation. *Since the human being is a member of a social group, and since he is in constant dynamic relation with people, the one primary source of motivation is the display toward the child of the best in human nature.* We have already raised this point as regards motivation through personality contact. The ultimate efficacy of this motivation lies in the fact that the *whole conditions the activities of its parts.* The human nature-pattern surrounding the child develops the child.

The Cultural World of the Young Boy and Girl. The child, a primitive human being, loves fairy stories, folklore, simple legends and songs. This representation of culture reflects life in a way that the child comprehends directly, without analysis; he lives the situations described to him. For example, how often one hears the expression: "Daddy, tell me a story." Everything the child experiences belongs to a world that, for an adult, would be a story-world and a play-world, but for the child it is real and serious. It is life. And through stories the child learns.

Cultural Values at the High School Age. Then, in the early teens, the boy and the girl live in a different world. It is a world of adventure, of exploits of great men and women, heroes who are worshipped, a world of the simple creative and expressive arts: manual, domestic, dancing, painting, and the more complicated games. Any subject like writing, reading, geography, history, mathematics, not having meaning in connection with this world, is senseless. Reading is mastered quickly if it pertains to this world. Books of adventure, invention, and fantasy are devoured.

But already, in the curriculum, school subjects have been

abstracted from their setting in life and made formal. Textbooks written from adult standpoints are organized to make possible the routine of exercises and drill; they abstract the facts from life and from each other in an unhealthful, artificial way. Although the textbook situation is much better than it formerly was, there is still much geography, history, spelling, rhetoric, and mathematics that is taught as if it had nothing to do with life and culture. By the time the boy and girl reach the later teens, when they are capable of sensing deeper values in life, the romance and the adventure in serious learning have already been subdued for the lack of the facts of culture to feed upon. And there is no excuse for it! Every normal child is eager for new information on any subject. But by now many aversions have been acquired, because instruction, meanwhile, was wanting in life-values. Mathematics has already become a bugbear. *There is unlimited romance and life in mathematics, enough to inspire any average pupil, but the textbooks do not contain it and the teacher does not know it.* What were the struggles and problems of the Arabs that led them to invent the system of notation we use today? What were they thinking about when they did it? There are legends that surround almost every number from one to ten, and reasons why the different digits have their particular shape. There is a simple philosophy of life behind each mathematical discovery, behind the discovery of *o,* behind the processes of multiplying, dividing, adding and subtracting, behind fractions and long division, and behind algebra. Why is not the development of culture in the race, the simple logic and philosophy that at each stage demanded mathematical inventions and discoveries, taught with mathematics? It is because adults, chilled by practicalities and utilitarianism, hardened by conflicts and commercialism, have forgotten how to live, and have lost their appreciation of the fact that the mainsprings of life are cultural, after all, not material. They prove this by clinging to immaterial values on Sunday, and abandoning them the rest of the week; by professing the necessity of intangible worths and confining them to their imagination, while they deny them in the actualities of real life. They become dualists and hypocrites, satisfying their idealism theoretically, and their utilitarianism in an artificial

world of affairs. It is this artificial world for which they prepare their children at the cost of not making immaterial and intangible values of practical worth.

Through history, and the physical and biological sciences, the student should learn what the good life meant to the Ancients, to Medieval man, to man of the Renaissance, and what it means to modern man. Through literature and history of religion and the arts can be acquired direct knowledge of the idealisms and struggles of the race for higher conceptions of values, for greater freedom from ignorance, for a definite conception of his own place in nature, and for progressively higher types of artistic and moral expression. Through instruction, taken as a whole, the student should learn of man's struggles with problems that his own inventions and modes of living have created. He should know the *difficulties* as well as the *advantages* that have come with civilization. (Bode.)

The Cultural World of the College Student. But because, throughout the curriculum, the philosophical and aesthetic aspects of each school subject at each level of difficulty have been neglected, their real values in terms of life itself are missed. No wonder students entering college have a vague idea that they are after something without knowing what! No wonder that for the most part their interest in learning is meager through indefiniteness of a cultural goal whose meaning has been taken away. Why should they not expect that, aside from the newly found thrills of their physical being, life no longer means anything real big and good and grand! They have lost the original spirit with which they looked at life as children. Their 'souls' have starved, and now they are relatively dead. Why should they expect an awakening?

Meanwhile, romance, the life of the late teens and early twenties, shut off from contact with the world of culture upon which it naturally must feed in order to be directed into constructive and creative channels, lacks the goal of wholesome idealism. It must seek its outlet too exclusively in *uncreative* pursuits, the cruder sports, gambling, premature indulgence, the trite, the crass, the vulgar, and the bold. Disillusionment comes to these who once had ideals before they were subjected to years of drill and drudgery; and, as a consequence, cynicism, skep-

ticism and a pathetically blasé attitude result. These are the consequences of our educational system. Fortunately, however, the college youth is still a child at heart, still natural, still idealistic underneath, as shown by their unfaltering response in human crises of any kind. But it takes an unearthly jolt to arouse most of them from their acquired lethargy, a terrific pounding to crack the crust of indifference. Mirror the broader problems of life as they have been and as they are, in a way that will make evident, without forcing, the constant need for constructive thought, and the thrill of it. Then the problem of motivation through the high school and first years of college has been solved. But it is too late to begin with the Freshman in college!

Motivation Summarized Under Organismic Laws. 1. *The Law of Field Properties.* A motivated act must be studied as a totality. Thus, properties which are often regarded as motives, namely the feelings and emotions, are not processes which act upon behavior. It is convenient to think of feelings and emotions as field properties of energized response. In this sense they represent an increased amount of energy available for differentiation toward a goal. This means that the motivated act brings the individual to his goal more rapidly and with increased efficiency.

2. *The Law of Derived Properties.* The value that a given feeling or emotional process will have is derived from the total organization of the behavior-act in question. For this reason a motive that is efficacious in one instance will not be efficacious in another.

3. *The Law of Determined Action.* Whether a given motive will be effective or not depends upon the total behavior-pattern of the individual; or in other words, upon what the individual desires most at the time. To have its desired value, therefore, a particular motive must fit the trend of the individual's behavior at the time the motive is given. The motive must be applied in the light of the individual's total personality, and in the light of main goals or interests whose fulfillment may be in the distant future.

4. *The Law of Individuation.* A motive is given in order to direct an individuation process. Again, therefore, since the

individuation is a process of going from a whole to its parts, the motive must be relevant to the organization of the total behavior-pattern.

5. *The Law of Field Genesis.* Any modified act is an expanding and differentiating whole. Any effort to split it up into parts and to induce the development of one part out of relation to the others ends in disorganization. A motive applied without understanding the individual as a whole, or the character of the motivated act as a whole, defeats its own purpose.

6. *The Law of Least Action.* Motivation comes under a corollary of the law of least action, namely *the law of increasing energy.* To motivate means to bring the individual nearer to his goal where he possesses more available energy for the execution of his task. The goal can be brought nearer by increasing its attractiveness or by reducing the problem to be solved to the level of the individual's insight at the time.

7. *The Law of Maximum Work.* Motivation increases the amount of energy available for work. It raises the maximum by altering the conditions under which the law operates. Furthermore, any effort to increase the efficiency of any part of a complex act must increase the efficiency of the act as a whole or else there is no effect at all.

8. *The Law of Configuration.* The effect that one motive will have depends upon the effects that all other motives are having at the time, which means that the same motive that will be effective in one situation will be ineffective in another. Each situation, where motives are demanded, is a problem in itself to be solved only by studying it in its relation to its own total situation.

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CHAPTER XXIII

DISCIPLINE

The Necessity for Discipline

Helplessness of the Child. Discipline is necessary. This indisputable fact follows from the very nature of the child himself. In Chapter XI a study of the child-as-a-whole revealed many characteristics that explain why direct and insistent supervision of child behavior is of paramount importance. First, the child is born helpless. He knows nothing and therefore has everything to learn. Second, the child's mental life is at first undifferentiated in all respects. He does not live at the outset in a world of specific and recognizable sounds, colors, shapes, sizes, distances and motion. He cannot discriminate. His motor activity begins, as we saw in Chapter IV, in undifferentiated movement. The world of action, space, time, location, objects, must gradually come into existence for him through an expansion and differentiation process that covers years of time. Third, the child's world expands from within. It begins with himself, although it can hardly be said that, at first, he has a concept of himself. This self-centeredness of the child's world means that at the outset he is a non-social being. He is selfish. In proportion to his strength he is rough, not gentle; through ignorance he is at all times unintentionally 'cruel' until he learns of sympathy and carefulness; knowing no values he is destructive. Having no idea of possession he is appropriative.

Fourth, the child is growing; his mental life is expanding; he is accumulating nervous energy which demands expression. He is a born investigator and explorer. His spontaneity is untrained, uncurbed; his curiosity is unbounded except by the limits of his maturation. Thus he is living a life of desires and wants that must be gratified, of interests that must be satisfied, of goals that must be reached. He has no inhibitions because he lacks insight. The natural thing for him to expect, with only

himself as a point of reference, is immediate fulfillment of his demands. His goals are all immediate and demand immediate attainment. He must learn to *postpone* his goals.

Attitude of the Disciplinarian. The consequences, for adults, of the child's demand for freedom and exploration, are frequently factors that condition the attitude and the spirit in which discipline is administered. These factors are impatience, desperation, embarrassment and anger. Unnamed and unanalyzed, they are often the reasons for his discipline, as apprehended by the child. But this is not all. The attitude of the parent toward the child is not confined to that of authority. There are the pride, love and joy with which the child is responded to, and his behavior directed. He is played with, shown off, remarked about in innumerable ways that prove to his insight, undeveloped as it is, that he is a mighty important person in the world. This sense of importance is not lessened when his side is taken in a family controversy, or, when in difficulty with the neighbor's children, he is unreservedly defended.

By the time the child is ready for school, therefore, his need of discipline may be caused by five or six years of mismanagement in the home. There is the over-indulgent parent who has promoted a hyper-aggressiveness in the child and has deprived him the opportunity of understanding reasonable forms of inhibition. His idea of the world is one which, still, should meet his demands. There is the fussy, over-cautious and overbearing parent who permits the child no initiative until initiative is forgotten; the world is one from which to expect no lenience and little kindness. This is all of the outside world, for no other world exists. The ideas and attitudes which he has already acquired are those with which he must anticipate new experiences to be initiated by a larger environment. He must understand them when they come, and the home gives him this understanding.

Disciplinary Problems in School

Consequences of Discipline. The troubles confronting the child in school, granting the teacher is a good one, are none

other than those induced by pre-existing attitudes, ideas, wishes, all manner of behavior-patterns which are resolving all manner of pre-existing tensions. These behavior-patterns are continuing to expand and differentiate in the larger environment. Other things being equal, the line of their development has already been laid down and they are continuing their course of growth. It must be remembered that misconceptions, untruths and maladjustments, as well as correct ideas and normal modes of response, undergo maturation. The former, as well as the latter, find stimuli in any ordinary environment which induce them to expand.

Over-stimulation. Most of the difficulties encountered with normal children may be grouped under the two heads, over-stimulation and under-stimulation, and probably more children suffer from the former than from the latter. The over-stimulated child presents a typical behavior-pattern. First, he is nervous; he neither can, nor wants to, sit still. His reactions scatter over a wide range in quickness but they are constantly changing. Whereas, all children can concentrate upon a single task for only a short time, he fluctuates even more. If another member of the class is reading, he is not following the book; he is looking around watching everything that goes on. Second, he is fatigued more easily than the average child. He has less reserve, sleeps less soundly, and generally eats less well. He is easily discouraged, and at times is difficult to motivate. Patience and tact are required in order to obtain a response in little things. Third, somewhere in the life of such a child there is almost certain to be a crossness, quick temper, and high degree of sensitiveness and jealousy. He is pouty and sulky when things go wrong, and easily made to cry. Exactly in what situations these traits will appear is not predictable, but generally they appear whenever the child is under stress, as when his desires are not fulfilled. The life of such a child is highly emotional and the emotions are of all sorts, covering a wide range of situations.

Fourth, the over-stimulated child is generally a leader, and frequently well liked. In some instances the aggressiveness is obnoxious, depending upon the character of the environment from which he comes. His aggressiveness interferes with self-

control in the classroom; he talks to his friends, if not out loud, at least in noisy whispers. And again, in accordance with manners already learned, he disturbs the classroom with his pranks. Fifth, the over-stimulated child is more than normally suggestible, especially in social situations. The suggestibility may be positive or negative, depending upon the situation. While one may be the first to volunteer in some co-operative enterprise, another will be the last. He is the type most likely to be bored.

The causes of over-stimulation are legion. It follows inevitably where there is bustle in the home; much automobiling through the country; permission to remain up nights; where parents are uncongenial, high-strung and changeable; where sharp forms of discipline are given; and where the child is pushed at home and in the school. The teacher must then treat the child with gentle firmness, be deliberate and cool in her attitudes, cautious in her demands, and watchful that she does not accentuate his condition by forcing him to continue a task beyond his normal limit of endurance. She should enrich his curriculum without advancing him too rapidly beyond his grade.

Under-stimulation. First, the under-stimulated child is generally unhappy. The unhappiness is not due necessarily to unreasonable discipline but to lack of other opportunities for self-expression. Second, this type of child is lethargic, slow to grasp ideas, and slow of movement. He is likely to be expressionless, and to show little interest in what goes on around him. Third, if pressed for response he is negative, shy, withdraws, and perhaps shows genuine alarm. Fourth, he is generally non-social, talks very little and avoids social groups. Fifth, he is submissive but, outside of shyness, is co-operative, although his responses are short-lived. He will answer verbal questions in monosyllables, and yet his written work may equal that of other children, if he is given ample time. Sixth, he is not necessarily dull and may be the child who, in playing by himself, is revealing the possibilities of superiority in intelligence and creativeness.

The causes of under-stimulation are uninteresting social environments where there are uneducated, sluggish parents, perhaps of strict fundamentalist faith, who abhor spontaneity,

play, gayety and mirth. The home is drab; and from infancy the child's activities have been curbed, not so much by discipline necessarily, as by the tomb-like atmosphere around him. Seeing so little within his reach he has developed few desires, and lacks the energy to rebel. The teacher can help such a child by showing spontaneity, brightness and animation in her attitude toward him. Without pressing, she can encourage him to engage in activities, but effective rehabilitation requires continuous effort. Such a child needs the taste of achievement in social situations; hence the teacher should reveal confidence in him and assign projects to be done at home, and to be discussed in class or after hours.

A Group of Emotional Patterns: (1) Tantrums. The child is not a stable individual. His lack of inhibition and his demand for immediate goals prevent him from being stable. But lack of stability is by no means a sign of abnormality, unless exaggerated and chronic. A common form of temporary instability is the *tantrum,* where the child, not securing what he wants immediately, forthwith enters a rage, displayed in a variety of ways. He becomes red in the face, strikes out at the person who has thwarted him, pounds and kicks, screams and cries with anger. Perhaps he throws himself down, thrashes around, pounds his hands, and even hits his head against the floor. Tantrums first appear, generally, at about the age of three when the child first discovers that he can 'work' his parents, or that, from his standpoint, the discipline he is receiving is unreasonable. Situations that produce injured feelings, jealousy or the anticipation of fear, may then become the cause. Quarreling at home in front of the child is quite frequently in the picture. Playfulness between parents, interpreted seriously by the child, will excite a tantrum, in which the child rushes to the defense of whichever parent he thinks is being worsted. Discontent in a wealthy home where little is seen of the parents, or, in the poorer home where tasks are imposed when the child would prefer to play, are other causes. And finally, over-stimulation and fatigue predispose the child to tantrums.

Treatment of the tantrum depends in large measure upon its cause. Remember that it is frequently a symptom of an irritated nervous system, with little reserve energy. The treatment

should not increase the irritation. At best, discipline is bound, momentarily, to intensify the child's temper, for he is *already resisting some form of interference with his desires, and the tantrum is deliberate even if spontaneous.* If it is not too stormy, merely ignoring the display is best. Quietly talking to the child is effective provided sufficient resourcefulness is employed in suggesting something striking for the child to do, but is not likely to work while the activity is at its height. Restraining the child's movements will inevitably make matters worse. A sudden change of stimulation such as a dash of cold water in the face that shocks him into forgetting the cause of the tantrum is perhaps as good as any method to use when interference is necessary. Whatever of this nature is done should be done quickly, *without show of anger.* Surprise is the secret of the treatment. Laughing at the child is fatal; and never should coming out of a tantrum be rewarded.

The reasonable way in which to treat the tantrum child is of course to remove the cause, and, while he is in a co-operative mood, to discuss the matter with him. The average child can be made to understand how tantrums never win him anything (provided they do not) and the maturation of these ideas will, in the end, eliminate the trouble.

(2) **Sulkiness.** The sulky and pouty child is generally the over-stimulated one, who receives insufficient comradeship from his parents. The average child will accept discipline from his parents if, on other occasions, he receives the joys of friendship and mutual confidence. He is then convinced that his parents are interested in *him at his level of living.* Sometimes, sulkiness is an outgrowth of *too little discipline.* Then, it comes when the routine of having his own way is broken, or, as occasionally happens, *when he deliberately sulks to break the monotony of indulgent attitudes toward him.* The child, socially unhappy for any reason, is either a potential or actual pouter.

(3) **Talking Back.** Talking back has a psychology of its own. In the beginning, *the child is merely returning what he receives.* Means of correction have been faulty. The child takes for granted that any manner of speaking *employed by his parents is proper.* Accordingly, when the parent speaks sharply to him, he will speak back sharply. In terms of

dynamics, it is action and reaction. Any sudden method of disciplining, vigorously enforced, will elicit a vigorous and sudden reply, either in the form of resistance or of crying. Expressions like, "Keep still, will you," "Hurry up I say," "Do this at once," "What is the matter with you," encourage back talk. No one is normal who would not reply in like vein. The way to handle this type of difficulty is obvious, a changed attitude on the part of the disciplinarian. Anger begets anger and should never be employed in corrective methods.

(4) Jealousy. Jealousy grows out of self-centeredness. The child, therefore, is inevitably jealous. Even pets around the home will advance for attention when they see children receiving it! Jealousy is subjected to control by not showing partiality and favoritism. Rewards and praise, or any form of attention, should be equally distributed among the group. It is imperative that this emotion be controlled because in exaggerated forms it leads to extreme negative reactions, suspicion and perhaps chronic social maladjustments.

From the standpoint of this problem the system of rewards for excellence, prevailing in the school, are not altogether to be commended. The child next to the leader in number of stars is normally jealous. While one must learn to share the joys of others without resentment, there are better ways of teaching sportsmanship than by putting temptations in the way. When the child is permitted to learn *for its own sake,* his idealism will prevent jealousy. Just as he receives joy in his own achievement, without a reward, he shares the joys of another.

Manifestations of Distorted Personality: (1) The Bully. Ordinary teasing, especially on the part of boys, is a common expression of aggressiveness. When it is a source of difficulty in school-situations, the victims of the teasing can usually be taught to laugh their way to freedom, or effectively to ignore the teaser. It should be explained to them that teasing is done for its effect and, lacking the effect, it will cease. Teasing is also a form of play and harmful joking, and the child who is teased should, within limits, be encouraged to give what he receives.

There are exaggerated forms of teasing which are signs of personality difficulties. The bully who picks on children much

smaller than himself is probably compensating for cowardice. He is 'taking out' on children whom he can subdue, the unpleasant effects of being a victim himself, generally of boys whom he lacks the courage to fight. Pathological teasing of this kind can be diverted into channels which benefit both the teaser and the teased. In certain cases he may be helped if pushed into a combat with the source of his terror.

(2) **The 'Sissy.'** The 'sissy' presents a serious problem for the reason that he has become socially maladjusted under conditions that can hardly be removed, namely, stupid management at home. Quite likely the father is a 'sissy' himself, or has been over-indulgent in his behavior toward the child. In other cases, the mother has shown the child, over the years, too much sympathy and has discouraged hardy independence. She probably leads him to school by the hand, permits him no contact with the 'rough' boys of the neighborhood, and in other ways teaches him to feel superior to the group. To make matters worse he is the butt of jokes and the object of derision in the schoolyard and in the community, generally. He lacks self-confidence on the one hand, or, in situations in which he obviously has the ascendency, becomes a bully. This type of bully generally selects girls upon whom to show his authority. In a situation of this kind the teacher's task is gradually to build up a boyish and sportsmanlike aggressiveness, not by showing sympathy, but by genuine interest and companionship. She should graduate the sternness of her attitude toward him as his confidence in her builds up, until he has learned to accept aggressiveness, even punishment. Meanwhile, she can reason with him, and not unwisely encourage him to engage in a deliberate scrap with a boy his own size. He must be taught to fight his own battles and to suffer defeat if necessary. Then, when he accepts defeat like a man, his teasers will respect him even if they win the fight. Once self-respect develops in his relationship with boys he will in all probability stop bullying the girls.

(3) **The Daydreamer.** Any pupil whose life is dominated by pain and distress will be a chronic daydreamer. It is in this world of dreams that he preserves the integrity of his personality. To punish for daydreaming means in cases of this

sort only to exaggerate the difficulty. Before the teacher exercises disciplinary authority over any daydreamer, therefore, she should take the trouble of ascertaining the cause of the dreaming. The daydreamer may be a pupil who has not received enough sympathy and recognition for achievement in the home, or, on the other hand, too much of it. He may be a constant victim of teasing in the neighborhood. Perhaps he has been over-praised and is imagining how great and important he is.

The traits of the daydreamer are exaggerated self-consciousness, often in the form of conceit; inability to make decisions; criticalness of others; a high degree of sensitiveness and susceptibility to hurt feelings. He is a poor sport; sentimental; usually very conscientious; highly motivated by rewards; selfish; suspicious of others; effeminate; socially uncooperative with other children; and is good at creating alibis.

Treatment in his case resembles that suggested for the 'sissy.' But it should be begun cautiously and with obvious sympathy. To ridicule the daydreamer or submit him to any form of social embarrassment is harmful, until his sensitivity is overcome through friendship.

There is another type of daydreamer, however, who is not maladjusted but an aggressive, ambitious, brilliant pupil who in daydreams is not indulging in self-pity and in 'getting even' with his tormentors. Instead, he is doing creative thinking, planning projects, building machines. Such a pupil may easily be led to co-operate in class if the teacher shares his interests and ambitions.

The More Difficult Problems

Lying: Causes. Lying is one of the most common forms of unco-operativeness in the school, and there are about as many different causes as there are lies. At the same time, however, the psychology of it is clear enough and treatment definite enough to make lying unnecessary. It is almost always a consequence of discipline. We have seen that a child is far less likely to understand discipline than most adults suppose. He resents not having what he wants and, under the law of least action, will spontaneously deceive in order to obtain his way

next time. When the disciplinarian is severe and frightens the child there is all the more reason for lying. Much damage is done the normal, wholesome attitudes of children by behaving toward them as if they were vile or degenerate because they lie. Honesty as a virtue is beyond the grasp of the young child. He must discover that honesty is practical in concrete situations. He will learn of its virtue in the abstract only through specific experiences in which the consequences of lying are intelligible to him. Until then, to embarrass or shame him does not teach him honesty. Unintelligible handling promotes cleverness in deceit.

Another cause of lying is lack of frankness in the home. When father and mother tell 'white lies' to one another, the child is certain to understand the situation sooner or later. He learns their weaknesses from them as well as how to eat at the table or how to dress. Again, children lie to obtain recognition for cleverness and bravery. Then it often commences in harmless exaggeration. Recall that for the child the world of reality and the world of imagination are at first undifferentiated. For this reason he fails at first to understand the significance of a lie and must rely upon the *attitude* of his parents to obtain a reason for the discipline. Many cases of lying are due to no other cause than slow differentiation of these worlds from one another. If the lack of differentiation persists too long the lying is 'pathological.' Other causes follow from a highly developed imaginative world constructed by the child to compensate for unhappiness. Lying follows, also, from bribing, which is always a vicious form of discipline. The child will 'work' his parents the instant he discovers they are gullible.

Typical Cases of Lying. The story is told of a mother who was greatly surprised, one day, when seven-year-old Mary spent her carfare for candy without saying anything about it afterward. The day previous the mother had said that she was going to town and that she would buy something for the child. Instead, she went elsewhere and returned without the present, leaving the matter unexplained. A situation like this is equivalent, in the child's estimation, to *any case* of not keeping one's word, and cannot be distinguished from intentional deception until carefully explained.

Many parents and teachers mistakingly assume that information about death, sex, and other matters pertaining to adult knowledge, should be garbled for the protection of the child. Thom [1] tells of a little boy whose grandmother had just died. The boy was very much attached to her, and in order to save him from distress and perplexity, his mother told him that the grandmother had 'gone to New York.' But the boy learned from children in the neighborhood *that the grandmother had died.* Being dead meant to the child being placed under the ground. This, in his estimation, was a most cruel way for his mother to treat the grandmother. He became resentful and hostile. This boy can be expected to lie when the occasion arises.

Treatment of the Liar. Treatment for lying requires utmost patience and tact. First, truthfulness must prevail in the child's intimate environment or there is little hope of preventing lying. Second, the impracticability of lying must be explained in simple, concrete situations *at the child's level of insight.* For example, Bob returned late from school and offered the excuse that the teacher had detained him. In reality, he played with some friends in the neighborhood. He had succumbed to social pressure from his comrades, one of the strongest motivating influences in child life. Then he lied for fear of being punished. The wise parent, instead of condemning Bob for *defying authority,* and making him feel like a culprit, explained to him that stopping to play with his friends was not wrong in itself, but that it might have resulted in inconvenience to *Bob,* and *incidentally* to the parents. During his absence in school, a ride might have been planned which would have meant some particular pleasure for him; when Bob does not come home without asking permission, his parents, not knowing where he is, could not get in touch with him should he meet with an accident.

Certain parents, suspicious that their children are lying, become angry and put them through a third degree *in the hope of catching them in a lie.* Nothing could be more detrimental to the child if a wholesome attitude for the practicality of truth

[1] Thom, D. A., *Everyday Problems of the Everyday Child.* New York: Appleton, 1929, 250.

is to be developed. Moreover, punishing children when they have voluntarily or nearly voluntarily confessed to some misdemeanor, *may be interpreted as punishment for telling the truth.* In cases of this sort, the child should be recognized for confessing, but not highly praised, and the seriousness of the misdeed explained. He must learn of course that misdeeds incur penalties, but at the same time must *understand the reasonableness of the penalty.*

The teacher's rôle in handling the prevaricator is to adopt kindness, and unqualified co-operativeness, but unmistakable firmness. She should first, by her attitude, eliminate fear and *edge her way* into the child's confidence. Then he may be encouraged to talk the matter over with her freely. Success in treating the liar comes in inducing a desire to tell the truth, but this cannot be accomplished if the child is *forced* into confidence, *and then into confession.* Kindness and understanding can easily be made obvious to the child with the proper inflections and quality of voice: "There was something you wanted, wasn't there? Maybe not now, but sometime, we might talk this whole thing over. You know, if you would tell me, sometime, I could help you, because, together, we might be able to work it out, next time, so that you could have what you want." The teacher should follow up the conversation, later, not permitting the child to think that she will drop the matter. After she has secured his confidence she must not forget her promise. She must direct the child into a situation where he wants something that she helps him to obtain by honest methods.

Stealing: Causes. Stealing, like lying, rests upon thwarted desires, irregularities of behavior in the home-situation and upon the activities of gangs. It is promoted by favoritisms that arouse jealousy, and by the denial of possessions like those of other children. *Children are extremely imitative.* When John discovers that Walter, up the street, owns a pair of stilts, *he* wants a pair; when Don is given money to spend, John wants some. Indulgence, as well as denial, may lead to stealing. A child soon becomes dependent upon luxury; this dependence undergoes maturation; then his demands become so great that even an indulgent parent begins to deny them. The child, now

a youth, steals to satisfy an expanded craving for possession. Stealing results, also, from social pressure. No boy wants to be called a 'sissy.' He steals in order to retain respectability in a gang of which he has just become a member.

Learning About Values. In principle, children should not be rewarded with money, must less bribed with it. On the other hand, they must learn its value, and that in ordinary life it is not easy to obtain. Thus, every child should be encouraged to work, not primarily for the pay, but for the advantages of co-operation. Parents, wanting a child to work for them, should give to the work an atmosphere of play. This is accomplishable even in washing dishes and mowing the lawn, but most parents will not take the trouble to figure out a method. In fact, many of them are at a loss to know how. Then, the work done, the parent should volunteer to help the child in something which *he* initiates. Pay can be introduced incidentally.

It was in this spirit that Katherine was induced to help sweep and to wash dishes. Later, the mother discovered that Katherine was trying to move her desk for the summer from its position in the playroom to the sun parlor. She seized the opportunity to return a favor, and volunteered to help. The work done, Katherine, without a word, went up stairs to her box of pennies and nickels and with great ceremony paid off her mother! (O'Shea.)

As in the cases of lying, humiliating the child and constantly reminding him of a theft he has committed, are fatal. Instead, the child must be explained the virtue of honesty through incidents and demonstrations at his level of understanding. Jimmie insisted upon stealing toys from boys in the neighborhood. It was discovered that he did not understand the rights of possession. He had never learned the meaning of deprivation or loss. He had always been given everything he wanted, which, unrealized by most parents, *never satisfies.* When he broke a toy his parents promptly bought him another instead of letting him suffer, for the time being, unpleasantness and inconvenience at not having what he wanted. He would then have discovered how valuable his possessions were for him, and could have put himself in the place of the boys whose toys he had appropriated. This type of stealing can be stopped by

object-lessons given with adequate explanation, and not in the spirit of punishment.

A Case of Stealing. Many an expedient intended to build up honesty in the child defeats its own purpose where the effort is done *group fashion.* Thom [2] tells of Tommy who, with the other children of the classroom, brought money for a school bank. The teacher listed the names of the children on the board with the amount that each had saved. Tommy was always at the bottom of the list because of economic conditions at home. Encouragement of the class to increase their savings was a source of anxiety to Tommy. The social pressure of the situation, including a desire on Tommy's part to please the teacher, led him to steal small amounts of money to deposit in the savings account. While of course *group projects of this sort have their value, they fail to consider circumstances in the individual case.* The teacher should always be on the watch, therefore, for the effects which such methods may have on the child at the 'bottom of the list.'

Stealing may accompany sexual irregularities when the individual is made to feel depressed and degraded. For example the parent and the teacher, alike, often commit the error of making the masturbator feel 'dirty.' Not infrequently the child is frightened into the belief that he will not mature to normal manhood, even that he will go insane. While masturbation is not to be condoned, exaggeration of its evils always produces unhealthful mental attitudes. When practiced to excess it is, like any other kind of intemperance, devitalizing; it may delay maturity; it may result in unhappiness in later life but largely through functional, not organic reasons. Moral pressure brought to bear upon the masturbator by unwise methods makes him feel unmanly, deprives him of self-respect, and in this way denies him the proper attitude toward the opposite sex.

It is imperative, therefore, that a difficulty of this sort be eliminated early without leaving the child with a sense of inferiority. When this is not done the consequences ramify into many channels. The boy or girl has already been made to feel that nothing is worthwhile; that he himself is not worthwhile. This represents a terrific tension that can be resolved only

[2] Thom, *op. cit.*, 242.

through activities that are congruous with their cause. These activities are anti-social modes of response. The whole governing the activities of its parts is a behavior-pattern that possesses the property of degradedness; it will condition performances that have the property of degradedness, namely, any act of which society disapproves.

The problem, therefore, is to remove the sense of guilt, explain the importance of the issue to the child at his level of understanding, appeal strongly to some other interest that can be expanded. Placing the child in positions of responsibility and rewarding by giving him another task with increased responsibility is the best way to build up the desired relationship of the individual to himself.

Stealing is also conditioned by its relation to the undifferentiated desires for excitement and adventure. The child learns in a vague way what stealing is; he learns of its 'thrill' from other children, who learned it from still others. He yields to social pressure and at the same time enjoys the excitement; consequently the stealing has a double motive. And finally, stealing emerges from the unwholesome and the broken home, where parents are unhappy, or the father is dead and the mother tied down with work. All of the more serious anti-social modes of behavior on the part of children come from social irregularities, excess hardships, or excess indulgences in the immediate environment.

Physical Causes of Disciplinary Troubles. Unrealized by many a parent and teacher, disciplinary troubles frequently arise out of no other cause than a physical defect. Any condition that marks off a child from his associates produces a gulf between them. Children are unsympathetic through lack of understanding; they are mercilessly frank and blunt to each other. Consequently the lame child is asked embarrassing questions about his lameness. This gives him the impression that he is 'not like other children.' He is pointed to, talked about, and in an infinite number of little ways compelled to be self-conscious. The child with a deformed hand, prominent facial disfigurement, and often the stutterer, carry this burden with them throughout life. It is too much to expect complete normality of attitude and of personality in such individuals. When

they do not show the effects outwardly, their inner life is replete with compensations. They daydream excessively where they imagine themselves physically normal and obtain the satisfaction of doing things as their comrades do; they 'get even' with those who withdraw from them or treat them coldly; they assassinate their tormentors!

But the hardship can be turned into an asset with the right attitude from the parent and teacher. Many great achievers in history have been individuals who, for one reason or another, found the way to surmount a personality burden of this kind. They have become great successes in proving to society that a lack of confidence in them was *wrong.* And society shows this lack of confidence in devious and sundry, but subtle, ways. Its attitude is always extreme. Children who do not show bluntness in terms of disrespect show it in terms of unbridled pity. Either attitude is calamitous to the victim's personality; either deprives him of self-respect. It is the same with adult society. Offers to help, well intended though they may be, do not exert the intended effect because the very attitude of help *tells the afflicted individual, already over-conscious about his condition, that he is helpless, if not defective.* On the contrary, he is as normal, in all other respects, as those about him. It is very difficult for a 'normal mind to dwell in an anatomically abnormal body.'

Methods of Discipline in High School. In general, discipline should take the form of reasoning with the individual, of finding out his likes and dislikes, and, through being an example, of pointing out to him in concrete situations the practicalities of good behavior. There is one route to success in handling youth. Inspire them. And, wherever discipline is employed it must be subordinate to inspiration. Here, the personality of the teacher, his enthusiasm for the subject he is teaching, his cleverness in motivating the learning process by ways that have already been suggested, count first as disciplinary measures.

The greatest difficulty at this period is the lack of a goal. Not having found one's self is a matter of not having a definite and absorbing interest. The student is not worked at his level of capacity, and interfering motives are allowed to creep into

the school-situation. In order not to incur his ill-will the superior student is given a good grade whether he earned it or not, and for similar reasons the inferior student is passed on. The athlete is protected for the sake of the team and the standing of the school. All of these difficulties must be ironed out before the problem of discipline in the high school is solved.

Two of the major factors in high school that bring on lack of co-operation from the student are *the nature of the curriculum and the character of the instruction in their relation to the adolescent period.* At this period, the girls need contact with women teachers and the boys with men teachers. Frequently they do not receive a sufficient amount of it. The assignments given a mixed class by a woman teacher too often fit the interest of the girl rather than the boy, and the assignments given by a man teacher more generally interest the boys than the girls. The efficient high school teacher realizes this fact and, whether man or woman, plans the assignments accordingly. The same problem arises in connection with the types of class discussions promoted by the teacher and the comments and side remarks which are made.

The Reasons for Maladjustments. Causes of maladjustment in this period go back to earlier behavior-patterns, to self-mortification at thoughts of sex induced by primitive religious concepts drilled into youth by ignorant parents; to excessive physical contact between parent and child over a period of years, such as petting and caressing; to lack of free discussion of life's problems between parent and youth; and to unreasonable restraints and fears on the part of parents where the youth is given no credit for intelligence. This is the time when the parents feel most keenly that they 'have no baby any more.' Their restrictions on 'his' behavior and their fears that something may happen to him are ways of preserving the parent-child feeling to which they cling.

Lack of companionship between parents and youth at this age is a general and widespread cause of adolescent difficulties. There are many fathers who keep from their sons any knowledge of their profession, their financial status, their own ambitions and ideas, and who play no games with them. To make matters worse, they take no interest in the ideas, attitudes,

philosophy of life, and personal problems of maturer children, even when asked. They answer questions in monosyllables, appear embarrassed, explain that they lack the time, and in many other ways, unwittingly encourage the attitude, "Oh, what's the use." It is one thing to say to an adolescent, "You are grown up now; take care of yourself." It is independence that the adolescent wants; a recognition of his own intelligence and initiative; but it is not a normal freedom to be isolated from friendship with one's parents. The parent must be willing to listen and to understand. He should let his children realize that he was young once himself and has not forgotten about it. Then the benefit of his wiser judgment should be given. It is a judgment given in greater wisdom but in the language and spirit of youth. The *teacher* must frequently become the adviser of the adolescent in intimate personal matters of all kinds, relating to physical and moral problems, ambition in life, religion, and vocational matters. The wider the teacher's interests in life, the more widely read, and the more highly cultured, the better disciplinarian he is when he admits the student to that culture.

Projection of Ambitions on Adolescents. And finally, adolescent troubles grow out of the projection of parents' and teachers' ambitions on their children and students. The individual's own interests often fail to agree with the desires or judgment of the parent or teacher, and more often than not the youth is correct. Nevertheless, the boy must go into engineering because of pressure from his father, when he has no aptitude for engineering; he is driven to enter the ministry when he has no desire in that direction. He is advised by his teacher to choose a profession because the teacher *likes* that particular profession, or, through prejudice, he is discouraged against a particular life work. Realizing the frequency with which trouble between adult and youth is caused in these ways, the teacher can avoid a great amount of unpleasantness, if not out and out grief.

The General Psychology of Effective Discipline

Guides to Discipline. From the discussion that has just preceded it is possible to draw a few generalizations regarding

the psychology of effective discipline. First, the disciplinarian is never successful who fails to put herself in the position of the disciplined. In every case of failure, its obviousness is always so great that it is never overlooked by the child, *and the child will always respond accordingly.* Second, it follows from this that discipline, given in anger, never achieves what is intended. Instead, it leads to further difficulties. Thus, at all times the disciplinarian should maintain poise. She is attempting to build up self-control in the child. Third, it follows also that the teacher must understand the mental processes of the child, the reasons which he assigns for things, his sense of values, and his motives. Then, maturer judgment, reduced to concrete illustrations and language, can be imparted.

Fourth, the teacher must be consistent, fair, permitting herself no favoritisms. Fifth, she should realize that the child's behavior at all times occurs in the course of resolving a tension, and that all tensions, whether normal or abnormal, represent disequilibration. She cannot correct a behavior-pattern by putting obstacles in the way of a goal; she will only raise the tension. *She must supply another goal* which means that she is substituting another tension, another desire. Sixth, action is a mode of preserving a balance in some behavior-pattern accruing to *the personality as a whole.* It is the whole child who is concerned; it is not the consequences of a particular act that should be uppermost in the estimation of the teacher. In order to give adequate discipline, therefore, *the teacher should know the total situation to which the child is adjusting when he commits a misdeed.*

Seventh, the child's motives are always idealistic, no matter how apparently wrong, until he has learned hypocrisy. Goals are their own rewards. For this reason a reward should always be an incentive to further *achievement,* never given as pay or as a bribe. Bribing in advance, like: "If you will study your lesson you can go home early," is in the long run a poor method. It is a poor method in any situation, for it promotes scheming on the part of the child to secure the bribe without going through the work. Eighth, threatening belongs to the class of incentives just mentioned. It is ineffective because it relates to something irrelevant, external to the goal, and therefore does

not organize the child's behavior-pattern toward the goal. On the contrary, it directs his behavior toward an easier method, that of avoiding the consequences of the threat. It is ineffective also, because threats antagonize. They challenge the child to 'dare' the disciplinarian. In the long run, he will learn to keep the teacher threatening as long as he can. Thus, the teacher is unwittingly encouraging negativism, boldness and hostility.

Ninth, wherever punishment is given, care should be taken at a later time to compensate for it, without suspicion on the part of the child that compensation is being given. This is the only way to maintain *rapport* with a disciplined child, and thus to guarantee co-operation next time. In his relations to others there must be an equal distribution of restraint and freedom. Each time the teacher prohibits, she must permit initiative, and co-operate in that initiative. *The Golden Rule is a law of dynamics operating in social behavior.* Tenth, punishment in public is deleterious. Any form of punishment produces an intimate relation between two individuals, and should be done privately wherever possible. Ridicule before the class, the use of shaming methods, like putting on dunce caps and seating children in baby carriages in a corner before the class, are always futile. They may bring the child to terms as far as the specific misdeed is concerned, but at the cost of further trouble for the individual, and will encourage shyness in social relations with other children. Either the punishment is all out of proportion to the misdemeanor or else the child will rise to the occasion, feign distress, and take the whole matter as a joke.

Eleventh, the teacher should remember that *many difficulties will iron themselves out if only ignored.* Numerous annoying activities are carried out simply for recognition. And as for the more serious difficulties, an attitude of pessimism and over-seriousness is detrimental to disciplinary success. The child is growing, normally, into a complicated environment, under natural law. This natural law, expressed in moral terms, is that the child will come out all right *if given a chance.* On the other hand, it is just as important to remember that a complete *laissez faire* policy and soft pedagogy eventually end in human wreckage.

Typical Cases Requiring Special Types of Motivation and Discipline. Under the law of determined action the child's personality is a product of his social environment in which the home figures most, and then the child's associates outside the home. The following three cases show that the child's work in school can be evaluated properly only in the light of his social situation as an index, and that the child's personality is the main index (given normal intelligence) of his progress in school.

Case 1. John. Eight years old. Third grade. Fifth grade reading ability. Mother spends much time with him, coaching and praising his work. No father. Mother compensating on only son. Boy has everything he wants. Developing superiority traits. (Law of derived properties.) Child generally disliked by pupils in room. Dominates in any free activity, ordering other children around. (Here child is transposing from the home to the schoolroom situation.) His brilliance is retarding development in the other children. Teacher always calls on him to recite in front of visitors, thus helping to spoil the child further. When another child stumbles in reading, spelling, or arithmetic, this boy is most often called upon to correct the error. Resentment and feelings of inferiority are growing in many of the other children. Thus, energy of the pupils is wasted that should be consumed in the learning process. (Pupils are responding configurationally to the total teacher-John situation and the atmosphere of the schoolroom which it engenders.) Tactful contact with the mother is demanded. (Law of maximum work.) The situation is difficult for John because less attention to John will now disequilibrate him. (Law of maximum work; John will resist a change in the *status quo* of his personality-pattern.) Possible solutions: (1) Keep John out of school for part of the time. He is accelerated in all subjects. (John is already over-stimulated and much of his intractability is due to a general irradiation pattern. Do not remove John too completely from his customary social relations for fear of disequilibrating him excessively.) (2) Send to higher grade, but this procedure raises additional problems, especially if continued over the years, and should be carried out only after careful study of the whole

situation. (Maturation should not be induced too rapidly. This brings John into social relation with pupils older than he, which may be a disturbing influence both to him and to his new associates—maximum work. Solving John's problem in the light of a total situation is following the law of configuration.) (3) Different treatment of John in the schoolroom. Gradually pay less attention to him. Could be sent more often to the library or given project work enriching his activity without inducing too rapid a maturation. (Principles of differentiation and expansion; providing goals.)

Case 2. May. Nine years old. Third grade. Dull; lethargic; shy. Co-operates well but progress slow in all subjects. Inclined to be ignored by other children. Is not receiving social stimulation outside the home. Economic status of family responsible for social isolation. Five brothers and sisters. Father away much of the time; mother too busy to spend time with children, who have little to play with. (Personality of May to be explained in terms of derived properties. Behavior-patterns not differentiated because of lack of stimulation. Is product of total home situation—law of configuration.) Problem: To stimulate May through personal interest in her (derived properties); to induce her to participate in social activities of the schoolroom and playground; to give her simple responsibilities whose fulfillment meets social approval, such as responsible rôle in group project work. (Make May part of larger whole—derived properties and configuration.) Other children might be encouraged to invite her to their homes occasionally, insuring, first, that her presence is welcomed and understood by the parents. (Parents influence children by being, for them, so large a part of the total home-situation—determined action.)

Case 3. Jack. Eight years old. Third grade. Progress average, but below capacity. Source of much trouble in schoolroom. Tattletale. Develops crushes. Exhibits air of sophistication beyond actual knowledge, for which parents are responsible, who have overdeveloped Jack's curiosity (determined action and derived properties). Suspicious and bold; compensated for unpopularity (least action). Family unpopular in neighborhood. Mother socially sensitive and suspicious;

critical of school and other children in front of Jack. The type whose own child is always right, regardless (maximum work). Jack developing deceitfulness at home and in the school (derived properties; transposition). Whole situation raises the question where responsibility lies. Mental hygiene of the schoolroom can be safeguarded only by securing co-operation from parents through efforts of teacher or special home visitor. Parents certain to resent interference (maximum work). Suggestions: Engineering frank talk with mother by those closest to her; reasoning with Jack in regard to his petty misdemeanors (inducing insight); giving him responsibility through project work (organizing behavior-pattern with respect to definite goals); participation in which he must at one time play a subordinate rôle, as with older boys, and at another time a superior rôle (to balance personality—least action). The boy needs to sense his true position in the social group and will not acquire that sense until given a varied opportunity (transposition and configuration).

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CHAPTER XXIV

THE LEARNING OF SPECIAL SUBJECTS—I

Reading

Introduction. The conventional psychology of learning, as we have found all along, misrepresents the process almost entirely. It 'gets the cart before the horse.' The view is a natural consequence of approaching a problem before it can be seen in its entirety. Seen only in parts at first, and then imperfectly as a whole, an effort is made to explain how the finished product *must have been a putting of the parts together under laws of repetition and association.* Nevertheless, teaching the school subjects has in many ways advanced in direct opposition to these principles. Improved methods in practical fields are frequently discovered before it is known *why* they are improvements. This has happened, especially, in the teaching of reading.

General Methods of Learning to Read: Previous Behavior Equipment. The reasons why a child can learn to read at all are, first, that he has already acquired a fair vocabulary of spoken words, and second, that he has acquired a perceptual type of response in which he sees objects in their brightness and spatial *relationships.* When the child is introduced to reading, no new principles are evident. He will commence with *wholes.* These are (a) a conception of a story as a whole. Stories have been read to him which he understands as completed units. He can carry in his own thinking, as a single expanding unit, a *continuous train of thought having a beginning, a direction, and an end.* (b) He understands a smaller thought unit, although he does not know, perhaps, the name for it. *It is a complete sentence.* He listens to sentences and understands them as complete thoughts, and he can construct them himself. (c) He has an understanding of names, as wholes, which stand

for objects as wholes. (d) Perhaps, already, he has become acquainted with single letters. In this case each letter has a meaning of its own as a sound, or as something that is concerned with speaking and writing, but its real meaning is extremely vague.

The Status of the Behavior Equipment for Reading. When the child is listening to a story or constructing one himself, the relationship of ideas to each other, or in other words their logical sequence, makes the separate statements intelligible. He has no idea that the story is 'constructed' of serial ideas or seriated sentences. He pays no particular attention to the place where one sentence ends and where another begins. He is like an adult so absorbed in a poem that he fails to notice how many stanzas there are, and how many lines to a stanza. Similarly, the child listens to a command, or asks a question himself, employing a subject, verb and object, without knowing in the least the mechanics of a sentence. *He does not need to know. The thought process as a unit determines where he shall put the subject, the verb and the object.*

The same principle holds for letters. A letter is worth nothing as an instrument to read with *until it is already in* a word. A child learns sounds perfectly and can pronounce them perfectly before he knows about individual letters; similarly, he learns to read without having studied the alphabet or knowing that such a thing exists. The alphabet is not necessary until one faces the problem of writing. Just as one story is distinguished from another by its major characteristics, which accrue to a theme or plot as a unit, so, one word is distinguished from another by the characteristics of its total configuration. The detailed differences need not be analyzed. As a total configuration, one word has a different pattern from another; it is longer or shorter, has peculiarities of tall and short letters, and so on, not possessed by the others, *but* the judgment of the difference does not depend upon noticing these details. It depends upon apprehending the total word just as a musician hears a melody, or the artist responds to a painting, or the infant to its mother's face. The distinguishing characteristics are total configurations perceived like a 'chord.' Differences between wholes are recognized long before that which makes them different is recog-

nizable. Then, as a recognition of the differences emerges, the gross differences come first, such as length, 'bigness,' one word with a 'big' letter at the beginning, and another not.

The Case of John: Lack of Analysis. Observations on the errors children make in reading give us a clear picture of their procedure. A certain kindergarten teacher always dismissed her pupils in the afternoon when they were able to recognize their name among others that she wrote on the board. It was John's turn. John was called either John or Jonathan at home and had learned to write his name in both ways. Their total configurations had the obvious field properties, for him, of length and general complexity. He never had counted the letters; that was not necessary. He did not know what all the letters were. The teacher called him Johnnie. He accepted Johnnie as his name when he heard it. He had heard the sound of 'ie' at the end of most of the boys' names in his room, but had no idea that the sound was represented by the 'ie.' In fact he had no idea what 'ie' was. It was not a whole in its own right, or a distinguishable part of any other whole.

The teacher wrote 'Johnnie' on the board with Freddie, Walter, Charlie and James. "Now, Johnnie," asked the teacher, "come up and point to your name." "It isn't there," said John. "Yes, it is," replied the teacher. There followed an altercation during which each continued to become more impatient with the other. Finally, the teacher said: "Johnnie, come to the board." When he was standing at the board she sharply asked, "Do you know your name?" "Of course I do," insisted John. "What is it?" continued the teacher. "It is John," the boy replied, very much perplexed at what the whole fiasco was about. "I can write it," volunteered John. The teacher permitted him to do so. Then John supposed that now he could go home, but the teacher made him stay until all the other children had left by the same route, successfully! Then she dismissed John in disgrace.

When he arrived home John said to his mother, "I'm dumb, I don't know my name." "Why, John," said the mother, "what do you mean? Of course you know your name." "Well," replied John, "the teacher said I didn't. She said she put my name on the board, but it wasn't there." The next afternoon

the mother visited school and witnessed a repetition of the performance. As before, John insisted that his name was not on the board. Then the mother said to the teacher, "John is called either John or Jonathan at home, and can write either one by himself; we do not call him Johnnie. Try 'John' or 'Jonathan.'" The teacher protested at first, saying that if he knew John and Jonathan, he certainly ought to know Johnnie. As far as the teacher was concerned John was either stupid or contrary, she did not know which. Finally, however, the teacher agreed to write John. She erased the list, put on some other names and wrote John among them. Up went John's hand immediately. "There it is!" he cried.

John, Jonathan, and Johnnie were three perceptual wholes. He was familiar with the first two as alternative written names, but not with the written 'Johnnie.' This was to him someone else's name. As a totality it was not like either one of the others. Remember that John did not see the individual parts of the word; they were not necessary for an understanding of the words or for writing them. When he learned to write from copy he learned both as totalities, not as objects constructed by adding so many letters together. He could not see that 'Johnnie' might be divided between the 'n's'; for him the word contained no 'n's'; it was an undifferentiated perception.

How often we make this mistake in teaching children or even in putting ourselves through a learning process. Wholes are simply not made from parts; parts come from wholes. The teacher thought the contrary, at least by implication, and difficulty with John was the consequence.

Lack of Transposability of Words. In the beginning stages of any learning process there is at first a lack of transposability. That is, an object is always learned *in a situation,* and granting no previous knowledge, it is a *strange object* when seen in another situation. This fact may be understood in terms of derived properties and accounts for the relatively stereotyped performances of the simpler animals, the feeble-minded and of normal, young children. A part has no independent existence. Therefore, when only one whole has been learned the meaning of the part is restricted by its position in the one whole. It means nothing anywhere as an isolated object. Seen in another

situation, the other situation determines its meaning, therefore the part cannot be recognized without going back to the whole, first, and proceeding to the part. The meaning of a part is never transposable. *A part will never transpose from one whole to another.* In the experiments on transfer of training it was found that learning a task with the right hand was 'transferred' to the left. The total nervous system was controlling another part of the same whole under the law of determined action. When the observer traced a maze with one hand after having learned it with the other the motions of the second hand were not strange, because there was already a total pattern that gave to all of its parts the functions learned by one of them. This is not hard to see. A gravitational system as a unit gives to all its parts the function of one of them, namely, that of falling toward the center of the earth.

An Illustration. Consider a child beginning to read. He learns a sentence in which he sees the word 'dish' for the first time: "The dish is on the table." Have him read the sentence. He knows 'dish' in this particular sentence. But now show him: "Please bring the dish to me." Mechanically tell him all the words up to 'dish' and, ordinarily, he will *not* know 'dish.' It is a strange word. Read the sentence in a way, however, that gives him the *thought* involved; he will point to each word, in its proper sequence, and now he knows 'dish,' but in this sentence-situation it is part of a new whole. And the new whole gives the word its recognition-value. A child will learn a word in a particular sentence-situation and use it many times *in sentences* where the weight of the whole gives him the meaning of the word. But show him the word, alone, and he will be less likely to recognize it. This means that the memorization of words through 'flash-cards' is an ineffective procedure.

The same words, capitalized in one sentence and not in another, are often *different words.* The same type of situation is found under the right circumstances in children's fears or, for that matter, in fears of adults and in their likes and dislikes. A child may develop a genuine fear of going to bed in the dark, but he is not afraid to enter a dark room to find a toy. A certain lecturer can speak with perfect ease before a large

class of students, but before a public audience of the same size he is embarrassed, though he may be giving exactly the same lecture. A child will refuse to eat tomatoes at home but let him dine at a friend's home and he 'loves' tomatoes.

General Method of Teaching to Read. It must be understood, of course, that in a text of this type the detailed psychology of reading cannot be discussed. On the other hand, the general procedures can be pointed out. First, the method of teaching reading depends entirely upon going from wholes to parts, if the method is to be effective. Where this procedure is not formerly adopted, and learning to read does take place, it takes place in spite of, not because of, the formal method of instruction. Seldom does a method, however faulty, prevent a child from learning something! Second, the teaching process depends upon beginning with a relatively simple whole and permitting it to expand and differentiate. Many primers are based, whether deliberately or not, upon these principles and more so now than formerly.

The child learns to read by *stories.* In practice then, the learning process commences by listening to a short, simple, interesting story, preferably one with which the child is familiar and one which appeals to his imagination. The teacher reads the story *clear through.* Perhaps the class discusses it and she asks the pupils questions. The more familiar the pupils are with the details of the story the more readily they will learn the individual words that they are to read; for then, if they should halt at a strange word, the thread of the story will suggest the word. Then the teacher returns to the beginning of the story and *reads the first sentence,* after which the pupils read it in unison or one by one, following each word with their fingers. In this way they read each sentence after her. Each word is recognized partly by remembering what the story was about, partly by remembering the sentence as a melody of sounds, partly *as a configuration of words* with each single word having a recognition-value given to it by the thought of the sentence.

A Case of Reading Difficulty. The average child who has difficulty in learning to read may be taught to improve through an appeal to a simple form of reasoning at the child's level. This is far more effective than any kind of drill. A cer-

tain child was at the bottom of her class. When she came to a given word she would fail to recognize it, although she had read it successfully many times before. Repetition and drill as such, be it remembered, are of no avail. Accordingly, when the child hesitated the teacher said: "Now tell me about what you have just read." *The child did not know. She did not know how far along she was in the story.* So the teacher re-oriented her to the story, and let her begin the sentence over again. This is the fashion in which the child *must* fill in the gaps, at first. In fact, at the outset, the child will come to an unrecognizable word in the second or third sentence of the story and insist, of her own accord, upon returning to the beginning. No better proof is needed that the whole conditions the activities of its parts and that the child learns by the whole-to-part method.

But now suppose the expedient of starting over again fails. Then the procedure is to help the child complete the *thought* of the sentence without looking at the page. Having completed it, ask her to read the sentence again. If the child employs a synonym, ask her to try again and generally she will recall the correct word herself. One self-correction of this kind is worth many promptings by the teacher.

Long and Short Words. It is the layman's belief that short words are easier to learn than long ones. Within limits, determined in part by the physiology of vision at the child's level of development, and in part by the distinctive or indistinctive character of the word as a total configuration, *learning a long word is as easy as learning a short one.* In fact two- and three-letter words are as easily forgotten as ten-letter words. This is because the small and large words, alike, derive their meaning from the same whole.

The Function of 'Repetition' in Reading: Transposition and Law of Segregation. Reading must follow the laws of expanding and differentiating wholes. The ability to recognize a word, no matter where, depends on a meaning derived from some *larger* whole. Then, seeing the word in any situation, and recognizing it, is a *transposition from one situation to another within this larger whole.* This means, in reading, where the number of words to be learned is large, that the child must

confront reading-situations repeatedly. *But this is not repetition of single words as such.* There is a corollary to the principle of transposition called the *Law of Segregation,* that *before an object can be perceived as a relatively segregated whole it must have emerged from a large number of relatively unlike wholes.* This makes transposition possible. The *field of experience* which is to give an 'isolated' word its recognition-value must become an *expanded unit.* Recall what was said a short time ago about the inability of the child to transpose at first. He will not be able to recognize an 'isolated' word until the recognition emerges from a whole that takes in *many* sentence-situations.

In order to accomplish this *the same word is repeated in a large number of different sentences, and in different positions in the sentence.* In fact, the principle we have just stated explains the ease with which children learn to read the old favorite stories which contain a great deal of reiteration, and is one reason why such stories appeal to the child when read to him. The reiteration of sounds is not alone musical and therefore attractive; each individual sound takes on more meaning when repeated in *different* wholes.

An Illustration of Transposition and Segregation. The following illustrates the kind of repetition upon which learning to read depends.

1. "Who will help me plant the wheat?" asked the Little Red Hen.
2. "Not I," said the pig.
3. "Not I," said the cat.
4. "Not I," said the goose.

And the 'not's,' 'said's,' 'the's,' 'pig's,' 'goose's,' are repeated in *other* situations, the words grouping themselves in larger or smaller meaning-units as the story unfolds. Each time a single word is used in a *new* context it becomes *more* familiar. *This is exactly the opposite from the situation demanded by the association theory.* The reason why 'repetition' *in different wholes* produces results is the fact that, while this process is going on, the reader is *discovering how certain configurational sequences of words demand completion.* The *particular* con-

figuration is not repeated; it is *different* each time, but *the type of demand is the same. This demand is based* on the dynamics of verbal thought construction. For example, take the two words, 'said the.' The adult reader knows that a noun of some kind is *demanded* after the 'the,' and the kind of a noun can be predicted from the preceding part of the sentence. Thus again, in the phrase 'stubbed his ——' one knows with practical certainty that 'toe' is coming. The same principle applies to all reading. It is not repetition of combinations, or a matter of associative strength, that accounts for the learning of words in variable contexts. The expanded whole that enables a child to recognize particular words when he comes upon them in any situation is this larger framework of rhetoric. He learns to read by discovering, without at first naming, the principles and laws of rhetoric just as a scientist develops a comprehensive theory.

Recognizing a segregated word is like recognizing the mathematical value represented in '6' when the numbers '1' to '10' are not present. The '6' has recognition-value, standing by itself, in terms of a conceptual whole which implies a range of values. The word 'goose' has recognition-value, anywhere, in terms of a vast conceptual whole which implies analogous ranges of experience where each part has been learned in relation to all the other parts. Stated more simply, the word is now familiar *as a word. The larger, more comprehensive, and more general the range of experience which gives to a word its meaning, the more certain the recognition of that word when seen by itself.* This is the *Law of Segregation* as applied to words. The part achieves segregation by having functioned in an ever-expanding whole; that is, recognition-value is derived by the word in proportion to the magnitude and abstractness of the whole of which it is a part. The more abstract the whole, and the more the transpositions that have been made, the more segregated the part.

A Comparison with Coghill's Results. It is important to note a close correspondence between what we have just said and Coghill's discoveries. He found, it will be remembered, that the embryo's first movements were mass actions, and that local movements of each part of the body individuated out from

the mass action, co-ordinated as they emerged. In addition, he discovered that *as local movements emerged the functioning of the total movement-pattern became less explicit and overt, but never disappeared.* For example, at first, the forearm could not be moved without an actual wave of overt contraction passing down the side of the body. Later, the arm movement could be made if sustained by a *tonus or posture* of the total animal instead of by overt body movement. But the whole is still functioning; only the evidence of functioning has receded from the observer's vision.

The animal's ability to make local movements of the body depends upon making many different kinds of local movements of the same part in different movement-patterns, just as learning to recognize a word depends upon seeing it in many contexts. Then, as a great variety of total movement-patterns is made, the wholes of which the local movements are parts become no more than postures.

Early in the reading process the whole sentence must be explicitly present before the word can be recognized. Later, the sentence, and all sentences that were formerly required for the recognition of the word, need not be present. The experience formerly represented in the explicit reading of the sentence corresponds to Coghill's mass action of the embryo. This reading process gives way to a general word-knowledge, a ground or range of experience that corresponds to the posture of the embryo. This general word-meaning 'surrounds' the actual perception of a concrete word, like 'goose,' as the posture surrounds the local movement. Here, of course, 'surrounds' is used in a dynamic, not a spatial, sense. What is meant by this can be demonstrated very easily by simply asking an adult a simple question. Show him the word 'goose' and ask him if he recognizes it. He will say, "Yes." Ask him how he recognized it and he will reply, "It has the *meaning,* goose." The *meaning* is the psychological 'posture' that sustains the 'local movement' in the total thought pattern and the 'local movement' is the recognition of the word.

Physiological Basis of Reading: Eye-movements. The speed of reading has been shown to follow the speed and the character of eye-movements. The eyes do not remain station-

ary but fixate a given place on a word, then another place, and another, across the line of the page. The eye-pause is the time necessary for the individual to perceive the word. The increase in speed which comes with the development of reading shows itself in a reduction in the number of these eye-pauses per line of reading matter. If the eyes fail to stop at the right place on a line there is a short backward movement. Backward movements are particularly prevalent in the beginning reader and usually occur in larger number toward the first of the sentence, immediately after the eyes have made the long sweeping movement necessary to pass from the right end of one line to the left end of the next. Sometimes a space is skipped by the reader, in the middle of a line, then more extended reversals are necessary. The eye-pause is a kind of *initial delay* necessary for a formation of the perceptual word-pattern. With proficient reading, just as in Snoddy's mirror tracing, the initial delays occur at less frequent intervals; there are fewer reversals and the distance between the pauses is increased. Not only do the pauses become more scattered as the reader increases his speed, but the pauses are more rhythmic in appearance.

The rhythmic progression along the line, necessary for rapid and efficient reading, is governed by a number of factors. First, lack of a general knowledge of the content to be read. This difficulty can be minimized by short advance discussions of the material to be read. Second, imperfect return swing from one line to the next. The reader should pause slightly at the end of the line to permit proper co-ordination of eyes in their movement back across the page. This is still another example of the initial delay. Reading material which has the same length of lines throughout is an aid to rapid reading. Illustrations in the center of the page and irregularities in the margin of the page are to be avoided whenever possible. Third, effective progression of eye-movements is reduced by trying to read more rapidly than the meaning of the material can be grasped. Premature speed necessitates looking back and pausing, thus going over material that has already been covered. If the reader understands the material as he proceeds he can maintain a rhythmic and steady pace. Fourth, the intrinsic difficulty of

the subject matter will inevitably slow the reader down and cause him to refer back to earlier parts of the line in order to understand the material. Fifth, if the material is uninteresting, the reader will not read for content, and therefore will make many reversals in order to pick up lost threads of meaning. The use of interesting material that the subject feels he must understand will generally overcome this difficulty.

Eye-Voice Span. The eye-voice span in oral reading is the distance from the word that the eye is fixating to the word that the voice is uttering. This span can be measured roughly by placing a piece of cardboard over the book from which the child is reading orally, and counting the number of words that he can read after the cardboard is in position. In the beginner the eye-voice span is zero. He cannot see the end of the sentence before he reaches it. The fine shades of meaning upon which expression depends, are not grasped until he has finished the sentence both orally and visually. Hence the child's reading is jerky and expressionless. The mature reader, on the other hand, has a large eye-voice span; he can see the end of a phrase or sentence before he reaches it and therefore can give the meaning and emphasis to the words that they are intended to have. The reader has seen the sentence as a whole in a more detailed and coherent fashion before he translates it into spoken words. Then he can group the words into a meaningful and expressive sequence before they are pronounced.

The eye-voice span is intimately related to the rhythm of eye-movement made in reading. In fact, the two increase together. Furthermore, just as the speed of reading and the meaning derived from the material increase together, so do the eye-span and the meaning of what is read.

Dynamics of Reading. Notice how the mechanics of reading follow laws of dynamics. In the beginner, the earlier, grosser and slower process is characterized by lack of control, uncertainty of distance and direction. The nerve-field has not differentiated into delicate alignments of potentials that will permit quickness and accuracy of eye-movement. This undifferentiated condition means the necessity of long pauses and short spans, quite similar to the situation pointed out by Snoddy in his mirror tracing study. Remember, also, how Snoddy found

that his adult observers were obliged, in the new situation, to restrict their vision to a small area next to the stylus. Children must restrict their vision to small areas around the visual fixation point, in order to see the *form* of the word, just as Snoddy's subjects were obliged to restrict their vision to a small area in order at this stage in learning to *perceive where* they were going. *It seems to be a general principle that the undifferentiated total-pattern requires all of its energy to produce a relatively segregated, isolated act; it can do only one thing at a time in a restricted way. When it becomes differentiated it can produce highly complicated movements, all coherently integrated. Then it can do many things at once.*[1]

In reading, when the nerve-field becomes highly differentiated, it can not only control rapid, accurate movements, but it can control extended movements where the perception span is correspondingly large. Here dozens of letters are taken in at a single glance, each one seen as clearly as any other.

More important, however, for the reading process, is the *control that meaning* of the passage exerts upon eye-movements. When the meaning is vague and the continuity broken, eye-movements are more numerous. It has sometimes been supposed that the eye-movements were *basic and that grasp of meaning* was dependent upon *them.* It is the other way around; the process of deriving meanings from printed words is basic and the movements are secondary;—they are only tools. This is demonstrated by the fact that previous familiarity with the meaning of the subject matter, obtained over other channels such as listening to the story, makes possible fewer and longer eye-movements. Again the whole conditions the activities of its parts.

Looking for Reading Difficulties. An important practical consideration follows from what we have just said. *Eye-movements are the last place to look for reading difficulties.*

[1] The history of any behavior-pattern seems to follow this law. The pattern as a whole, at the outset, exhibits simplicity of form and heterogeneity of action (unpredictable, so-called random activity). In the end it exhibits complexity of form (heterogeneity) and simplicity of action (predictable). This may be called the *Law of Reciprocal Change.* It is a corollary of the Law of Field Genesis. It finds striking confirmation in the evolution of animal life. Man is losing muscles, bones, and other organs but is gaining in complexity of form.

These movements should take care of themselves if the learner has discovered *how to apprehend reading matter.* The slow reader is not one whose eye-movements are defective; that is, short and numerous movements are by no means the cause of slow reading; they are symptoms. It cannot be said that the eye-movements are holding back the reading process; the reading process is holding back the eye-movements. Difficulties in reading must be sought, first, in the reader's intelligence, interest in the subject, and in lack of motivation. Second, they may be sought in a failure to discover configurations, that is, the inter-word relationships with which words of various kinds follow one another. This discovery is made, as we have said, long before the principles of rhetoric are understood; it comes in the expectation that words of certain meanings must follow others. It is based on an undifferentiated 'feel' for sentence construction, a response to the total-sentence structure. Recall that the goldfish responded to a total pattern of lights without in the least, if our guess is correct, knowing what he was doing. The fish proved this configurational response by *transposing.* The child proves the same thing when he is able to recognize a word learned in one situation when it is presented in another. In short, the difficulty in reading may be an inability to effect the right kind of transposition. Then the words should be presented in a greater variety of relationships in a greater variety of sentences. This method was substantiated even in the goldfish, for, when lights were placed in a variety of combinations, none of them repeated, they were learned more quickly.

Errors of Perseveration. A common error made in reading is the error of perseveration, a case of maximum work. An idea, any whole, will retain its *status quo* until something alters it. This is but a special case of a famous principle known to the physicist as Newton's first law of motion. A body given a certain motion or velocity will, other things being equal, retain that velocity permanently, unless acted upon by an outside force. This law is important because it means that errors are bound to be repeated in the thinking of the child, unless they are corrected. It also means that feelings, such as suspicions and all manner of attitudes, will continue and grow unless checked or counteracted, a process which frequently

takes care of itself, but often, not. The growth process itself is evidently a special case of Newton's law.

A typical error of perseveration, in reading, was made by a second grade pupil who persistently saw 'though' as 'thought.' She learned 'thought' first, and she had failed to differentiate the two words. The remedy, still again, is by expanding the whole of which the words are parts, through transposition. She was given sentences to read like the following: "I thought the dress was green, though Mary said it was blue." (Explain that 'though' means something like 'but.') "Grandpa thought I was a good girl, though I had been naughty." "Though it had been raining (another meaning of though), I did not get wet because I had an umbrella." "You thought I would get wet, didn't you?"

Correction by Creative Writing: DeBusk. DeBusk[2] has recently achieved striking success in correcting marked reading deficiencies by the method of creative writing. It frequently happens that, in children, the perception of words and sentences remains undifferentiated for abnormally long periods of time, even when normal progress has been made in other subjects. In these cases the behavior-patterns involved in reading require *intensified and diversified stimulation* before further differentiation will take place. This increased stimulation is often effective when given through kinaesthetic channels. Hence the child is asked to *write* words which he cannot remember. But sheer writing drill is futile. The child selects a picture, or draws one himself, and writes a story about it of his own invention. Through an enriched self-expression the child learns the feeling for words and sentences, and frequently, during a period of only six weeks, makes up for two or more years of retardation both in reading facility and range of vocabulary.

The reasons for retardation in reading are legion. The child may have failed to develop a feeling for sentence construction through lack of interest in reading. Interest in reading has failed to keep pace with an interest in manual expression, which prevents him from discovering how adequately to perceive words, visually. The difficulty may be largely emo-

[2] DeBusk, B. W., "The Persistence of Language Errors Among Children." Uni. of Ore. Publs., 1930, Vol. 2, No. 4; 1931, Vol. 2, No. 6.

tional and social, a matter of an inhibited personality. In any case the correction can be made only through motivation, self-expression, and more varied types of language stimulation, as through creative writing.

The Problem of Specific Drills. If one accepted a mechanistic conception of the learning process it would follow that, as a general rule, the way to avoid difficulties in learning would be to isolate these difficulties and to practice them separately and independently, by means of specialized drills. Indeed, by implication at least, learning should begin with the isolated parts and proceed by putting these parts together. Theoretically, learning to read should begin by learning the alphabet. Already that procedure has been abandoned in the school system because letters are learned from words. Words are not learned from letters. In order to complete the mechanistic program, flash cards, phonetic cards and word games should be employed. But these methods have proved unsatisfactory (Gates, Pennell and Cusack). Exercises designed to develop the special skills of which reading is supposed to be composed, do not as a rule achieve their intended purpose because *reading is not composed of special skills.* What mechanistic psychology regards as skills are products of reading, not causes. *They emerge, already related, in the reading process as a whole, or they never develop.* Some of these supposed special skills are: perception of words; perception of phrases; perception of dependent clauses; judgment of whether a given statement is true or false; ability to discover or choose like ideas; ability to discover or choose unlike ideas; ability to discover ideas that supplement each other; comprehending of different types of relations, such as whole-part, cause and effect; ability to solve a problem; ability to summarize.

If reading is intended to develop these 'special abilities' *they must be brought out by extensive reading of logically coherent wholes in which the particular processes just mentioned appear transposed from one context to another.* Special exercises are inadequate. This is because the mastery of a particular process comes about, not by repetition, but by deriving an understanding of it in constantly varying situations. The meaning of a particular process can be acquired

only by discovering the operation of that process in an ever expanding system of reading and language knowledge. The value of extensive reading has been pointed out by Field, Harris, Hulsether, McCallister and others.

Spelling

The Problem of Spelling. Spelling is necessary if the child is to express himself in written language. Although he may know the meaning of words and how to use them, unless he can spell, his written communication with others is unintelligible. Granted a partial facility in spelling and the difficulty is not removed, for words which sound alike are not spelled the same and frequently words are not spelled in accordance with their sound. The problem in learning to spell is to perceive a word as a whole in such a way that the detailed relationships of the letters are discovered, and also the reason for the particular place of each letter. The plan and also meaning of the word as a unit conditions the order of the letters, and unless the consequences of this fact are realized in teaching the child to spell, he will never learn.

Cornman's Experiments. Cornman[3] has performed an experiment on the relative merits of incidental learning and of drill in teaching spelling. He found that fifty schools which gave specific drill in spelling showed, in a subsequent spelling test, a score of 71.7 as compared with a score of 69.2 in two schools which gave only incidental instruction. The incidental method consisted in directing pupils to the dictionary, in correcting mistakes in written work and in displaying words that were likely to be misspelled. Cornman found, also, that the incidental group was superior in the use of words in sentences. This study, which is merely an example, *shows the futility of drill. The pupils who had none did practically as well as those who were drilled, and they could write better.* If drill is to be employed it must not be mechanical repetition, but time spent in understanding the reasons why words have their particular spelling.

[3] Cornman, O. P., *Spelling in the Elementary School.* Boston: Ginn and Co., 1902.

Reading in Relation to Spelling. There are reasons for believing that effective spelling depends upon a combined use of the incidental method and a systematic study of *problems* in spelling. The purely incidental method, unless carefully administered, may lead the child to think that spelling is of no importance. Distributed work of a rational type, on spelling as a problem, should be done on the same words that the child has been reading. In this way the word as a spelling problem is not divorced from its reading context as so often happens in the pure drill method.

Rôle of Practice in Spelling. Practice in spelling is necessary for the same reason that practice is necessary in reading. Indeed, the psychology of it is the same. Letters occur in different relationships in words just as words do in sentences. *In order to know exactly where a certain letter belongs in a certain word its relationships to the rest of the word must have been discovered and, often in addition, its position in one word as compared with its position in another.* This means that the letter must be repeated in a great variety of words, just as words must be repeated in a great variety of sentences, especially the letters that have relatively ambiguous positions like 'i' and 'e' in 'believe' and 'receive,' and 'a' and 'e' in 'existence' and 'instance.' Hence practice in spelling, alone, is fruitful. But, a warning must be reiterated. *If the teacher permits herself the bias that this repetition means learning by association her first impulse will be to forget the larger situation in which the letters must be perceived in their derived relations. This is because the association theory presupposes beginning with the letters and putting them together, a view that suggests the feasibility of merely repeating the same words over and over in order to fix them in mind. Such a procedure, as we have seen all along, does not promote learning. In fact it is detrimental to learning.*

Learning to Spell Rationally. Even the young child learns to spell by the whole-to-part method; the perception of a word as a whole determines the place learned for each letter. He learns most of his spelling from the sound of the words, but where the sounds are the same for different words the comprehension of larger wholes is necessary. For example, take the

words 'bear' and 'bare.' He learns to spell these words by erecting a range of information about them both in such a way that the spelling of the one is differentiated meaningfully in relation to the other. Both words must become members of an expanded whole of experience and take their place in relation to each other as words with different spelling according to their different meaning. Thus, the child finds that 'bear' is an animal and is spelled one way and that 'bare' is a condition of nakedness and is spelled another way. He learns to spell just as he learns to read by perceiving each troublesome detail in an ever increasing and varying set of relationships and not by drill or repetition of the same responses. Learning to spell 'instance' and 'existence' is achieved in the same way, by the expansion of information about the 'a' and the 'e' to a larger totality of relationships in words of various sorts having these endings. Unless the correctness of the 'a' or the 'e' is derived from the membership-character of the letters in this systematically studied whole *the confusion will always persist.* This larger whole may consist of an array of words ending in these two ways, where the rule for the use of the one *versus* the other can be seen in application. Where exceptions occur they can be understood, and not forgotten, if the exception is not given as an isolated fact, but in relation to the rule of which it is an exception. Every exception has a reason and if the child knows the reason he will not likely forget the spelling, provided the explanation is meaningful enough. The larger whole may also consist of rules of spelling made over into verses and stories where there is rhythm or action. Then the spelling is remembered in terms of the verse or story which is easier to recall than the spelling, owing to its greater motor or logical form.

The Logic of Spelling. If the sources of English words were told pupils who are learning to spell, and that folklore and culture fitted into the lesson which explains why words happen to be spelled the way they are, the task of learning to spell would be made much more interesting and easy. This could readily be done even for the primary grades. If the way a certain word is spelled meant something to the speller he would no more forget it than he would forget that 2 and 2 are 4. That 2 and 2 are 4 is not remembered because of repetition. It is

remembered because it means something, logically. Logic is *not remembered;* it is *thought.* The poor adult-speller is the one who never bothers to approach the task systematically and to see words in larger settings. The poor child-speller is one who, like the poor reader, has no 'feel' for the word as a whole, and cannot transpose.

Rules for Teaching Spelling. Assuming the major principles just outlined, the following supplementary rules may be observed as aids to spelling. First, the words should be presented in as many ways as possible. The child should see the word written on the board; it should be pronounced by the teacher; the child should pronounce the word himself and write it; the meaning of the word should be plain to the child and its usage illustrated. These procedures help to give each word a variety of whole-part relationships which make a more stable perceptual unit, and, being a more stable unit, it is more often spelled correctly. Second, the words that the child is given to spell should always be words that he will use immediately. He cannot remain interested in spelling unless he can see that the word that he is learning to spell is to be of some use to him and is something that he needs to learn. Third, the words should be presented for the first time in sentences, but thereafter should be presented alone. As the sentence gives the word its meaning it is necessary that the child understand this larger whole *first.* Fourth, long and difficult words should be presented in connected syllables. This does not mean that the syllables should be separated from one another, but does mean that the child can perceive the sounds of the syllables with respect to each other, which is oftentimes impossible in rapid pronunciation. Fifth, words that are of similar spelling should be presented *in groups* when possible. The child is able to perceive the differences between two words that sound the same, but are spelled differently, when they are presented in this way because a whole of which each is a part then becomes evident. Sixth, oral study is better than silent study. In the case of oral study the child pronounces the word at the same time as he is spelling it, and the sound of the word is an aid in spelling. In silent study the child is not so likely actually to spell the word, but looks at it

and only *thinks* that he knows it. Seventh, interest in spelling can be motivated by spelling contests between the members of the class or between other rooms and even other schools.

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CHAPTER XXV

THE LEARNING OF SPECIAL SUBJECTS—II

Handwriting

The Problem of Handwriting. It is a common misconception that the writing of the child should be 'letter perfect.' When one considers the prevalency of devices which take the place of writing, such as the typewriter, it is no wonder that writing is not as important as it once was. It is, however, necessary for the child to write legibly in order to sign his name and to teach others to write. Traditionally, learning to write is a dull task concerned mainly with drill in copying a good hand, in writing the same words over and over again, or in making 'horse tracks.' Under these conditions it is inevitable that the child often makes little progress.

Position in Writing: Freeman. It has been a common practice in schoolroom methods of instruction in handwriting to assume that a particular posture is one of the important factors. Some systems have advocated spending several weeks on 'correct' posture alone. Studies of posture, in good and bad handwriting, do not substantiate this claim. For example, from photographs of good and bad handwriters it was found that there was no one correct position.[1] One good writer held his pen in nearly a vertical position, another on a marked slant far to the right. The poor handwriter showed a large number of positions. One varied the angle as he wrote, another rotated to the left at the end of the line. The poor handwriters seemed to differ from the better ones in that they made a grosser movement of the arm. It is evident that the finer movements necessary for good handwriting had not yet differentiated. However, slumping over the desk or twisting the body in awkward positions restrict free movement of the arm muscles em-

[1] Freeman, F. N., *The Psychology of the Common Branches.* Boston: Houghton Mifflin, 1916.

ployed in writing, and should be avoided. This is especially true for beginners who must, in order to write at all, make more extensive body movements than the accomplished writer.

Analysis of Movements in Handwriting. (1) From what source comes the driving power of the writing movement? Both speed and accuracy of handwriting depend upon mass action of the arm. The driving force must come from above the elbow. If one attempts to write by making local, segregated movements of the fingers, one can develop neither speed nor accuracy. (2) The general feature of the writing movement is a posture of the arm which has developed the correct amount of tension to maintain the organization of the individuated wrist and finger movements. Then the latter movements must, in the course of learning to write properly, emerge from this arm-pattern, *integrated as they emerge.* The arm-pattern is *not* a combination of so many separate movements of the fingers, wrist and arm. The cycle is precisely that which we have found to operate all along in our discussion of motor co-ordination. (3) The good writer apprehends as wholes what he is about to write. He plans ahead, and in an *initial delay* period, 'sets' his arm for a unified movement-pattern, taking in a convenient unit such as a syllable or short word.

(4) The steps in learning to write follow the same order as the steps in reading. The procedure is that of an expanding, differentiating movement-and-perception-pattern. The young child must at first see grossly and move grossly; the totals which he sees are small and the 'local' movements which he can make are of short duration, with uncertain direction. That mass action comes first is shown by the picture of the child's first efforts to write. He grasps the pencil awkwardly, and not only moves his hand and arm but contracts the muscles of his face, twists his body into unnatural positions and clenches his left hand. Freeman [2] calls this type of initial response 'diffusion.' As the child matures under stimulation, the wholes which he can perceive and write as completed units become larger, and as they become larger, the greater differentiation of the pattern that comes with expansion gives a more precise direction to each line.

[2] Freeman, F. N., *op. cit.*

(5) Studies have not, as yet, determined accurately the correct system of strokes and pauses to be executed for optimum speed and beauty of form. Writing, like singing, is accomplished in wholes, but the configuration of each whole exhibits certain emphasis of muscular tension, spurts of speed, and pauses. The pauses are brief delay-periods in which the form of the succeeding movement is to be guaranteed. These come where there appear sudden changes in direction of lines or changes in complexity of pattern.

Handwriting movements can be studied photographically in order to determine the best places to pause and to make rapid, sweeping movements. The poor writer attempts to execute an entire word without varying speed or force at points which protect the coherency and regularity of form. He writes in a 'monotone' or 'expressionless' fashion just as the poor reader recites and the poor singer vocalizes.

Handedness. The literature on handedness is voluminous, but comparatively little is actually known about the problem. For example, are people left- or right-handed through inheritance or training? Different authorities interpret the same evidence differently. Taking all things into consideration, it would seem that handedness is a social inheritance, not a biological one. Recent studies on animals show that handedness extends down the animal scale at least as far as the rat. The early and frequent opportunities for the young to observe the hand movements of their parents indicate that handedness is 'imitated.' Evidence for the social heritage view is found in the insistence with which parents change over children who begin by using their left hand.

The Development of Right-handedness. It is probably a matter of *chance, at first,* which hand an infant begins to use most of his own accord. But there is relatively little opportunity, in the nature of the case, for him to continue using one hand as much as the other. To illustrate, the mother almost always extends objects to him with the same hand, generally the right. This movement is perceived by the infant in its spatial relation to the mother's body. This in itself would predispose him toward a 'one-handedness.' The picture is not complete, however. When the mother hands him objects she

never extends them straight from her but, under the law of least action, diagonally toward her left. It is more difficult, owing to the anatomy of the arm and body, to make movements in a direction at right angles from the body. This requires co-ordinating both the extensor and flexor muscles, while extending the hand diagonally to the left involves a simpler extension movement of the muscles at the back of the arm. This means that the object reaches the infant, in a greater number of instances, *on his right,* and he responds under the same law of least action with the arm that is nearest the object to be grasped.

If situations of this kind occur with greater frequency than any other it means that the neuromuscular system on the right side is receiving the greater amount of stimulation. From the account of the nervous system given in Chapter III it was seen that the nervous system is bilateral, that is, the brain on the right side generally receives from the left side of the body and discharges into the left side, and *vice versa.* The left cortex, in right-handed activity, would therefore undergo more maturation than the right, although all of the brain is involved. This means that there would be a gradient of maturation across the hemispheres.

Consequences of Changing Handedness. It is well known that changing over a child to the right hand who has developed left-handedness is a disturbing influence in his development. There are physiological and psychological factors involved. After the gradient of maturation has developed from right to left, as in left-handedness, the major lines of nerve discharge, as far as writing is concerned, are from the right cortex. Suddenly prohibiting the child to use the left hand in manipulating and writing disequilibrates the entire brain. For a time his whole movement-system is thrown back to an earlier stage of mass action, with its gross types of response and awkwardness. This awkwardness is not only shown in hand but in all body movements requiring delicate co-ordination, including speech. The whole situation discourages the child, makes him self-conscious, and increases his emotional tensions. These in turn exaggerate his awkwardness, and if the child is not treated with proper consideration the cycle becomes a vicious circle.

There is no physiological reason, yet discovered, why a

child should not be left-handed. There are certain practical reasons which need not be discussed, except to remark that none of them are important enough to justify the risk of changing over a child from the left to the right hand after he has developed good co-ordinations with the left. The suppositions that left-handed children have something wrong with them or are handicapped because the left hand cannot be co-ordinated as well as the right, are nothing but superstitions based upon the popular preference for the right hand. Left-handed and two-handed (ambidextrous) individuals, other things being equal, are as normal in every respect as right-handed individuals.

Handedness and Stuttering: Travis. Recent studies by Travis,[3] indicate that many stutterers have been children who were changed over from the left to the right hand. While this is not, in all probability, the only cause of stuttering, it seems reasonable to suppose that it is one of the major causes. The plausibility of this view rests upon the dynamics of the neuro-muscular system. It is well known that the part of the cortex, functioning as the line of least action of motor discharge into the speech muscles, begins in the so-called 'speech center.' This center is in the left cortex when a person is right-handed and in the right cortex when the person is left-handed. The lines of greatest discharge to the speech and hand muscles arise from adjacent sources in the cortex. There is a physiological reason for this. Each part of the cortex takes on its function in accordance with what is going on in all other parts of the cortex at the same time. That is, a gradient of maturation determines the rôle to be played by each locality within it. The anatomical proximity of the most direct motor routes both to the arm and speech muscles, and the almost constant use of the hands during acts of speaking (making gestures, talking about objects being manipulated), means that the differentiation processes in these two centers will occur together. The high peak of the cortical gradient that subserves speech *will follow the gradient for hand movement* instead of developing against its resistance. The

[3] Orton, S. T., and Travis, L. E., "Studies in Stuttering: IV." *Arch. Neur. and Psychiat.*, 1929, Vol. 21, 61-68; 386-391. Also Vol. 22, 487-494. Travis, L., *Speech Pathology*, New York: Appleton, 1931.

speech and hand gradients coincide under the laws of least action.

If this is true we can readily understand why changing over the hand would predispose the child to speech disturbances. The whole brain is disequilibrated and the speech gradient no longer fits into the total pattern. It must change, also, in the course of re-equilibrating the brain. Both new gradients must develop together. Some children are able to effect this change without disastrous consequences especially if the emotional situations involved do not exaggerate the difficulty. However, if the child develops awkwardness of speech and loses confidence in himself, stuttering may arise as a combined consequence of brain disturbance and a psychological loss of control over the speech muscles.

How Children Stutter. Children stutter with their whole bodies, it is not alone a matter of throat muscles and vocal cords. Investigations in the Speech Clinic at the University of Iowa, under Travis, show that 'stuttering' movements involve the eyes, and, as is obvious, the muscles of the chest, the face, arms and abdominal muscles. Indeed, the stutterer is a completely disturbed neuromuscular system. This is to be explained under the law of maximum work. The total neuromuscular pattern is disturbed when one part of a behavior-pattern is disturbed, such as changing over from one hand to another or when there may be something organic or anatomically wrong with the muscles of speech. The disturbance is the energy of the whole expending itself to the end of returning the entire system to a state of balance.

Methods of Teaching Handwriting: Thorndike and Brooks. Handwriting, like spelling, has usually been taught by the pure drill method, although studies have been available for some time proving that the drill method is not effective. Thorndike [4] discovered no consistent relationship between the amount of time devoted to handwriting per week and the quality of the product. From a survey of grades VII and VIII in seven school systems he found that an average of 75 minutes per week gave no better results than systems which

[4] Thorndike, E. L., "Handwriting." Teachers College Record, 1910, No. 2.

devoted no time to it. Brooks [5] chose pupils of approximately equal ability from grades VI and VII. Three lengths of class periods were selected, 50, 75 and 100 minutes per week, for a period of four and one-half months. The three time-intervals yielded practically the same amount of improvement, although the shortest one (50 minutes per week) was the best by a small margin. Formal drill, therefore, is a waste of time in the teaching of handwriting.

Effective handwriting can be promoted in the following ways: First, select material that is interesting for the child to write, or better, let the child write about something that he suggests himself. Keep the creative aspect of writing to the front at all times. Second, give only very short periods of practice in handwriting, not more than 10 minutes per day in the early grades. This is because the child is easily fatigued, and *irradiation patterns* quickly form in an undifferentiated nervous system. Third, teach the child position and form through actual writing and through corrections from the teacher; do not teach position and form as processes in themselves. Fourth, letters should not be taught separately and then combined into words. Follow the laws of expansion and differentiation of movement-patterns. Fifth, the child should be taught to criticize his own writing and to recognize where he can improve. He should understand at all times what a given correction means, and should be encouraged to make spontaneous corrections. Sixth, contests between members of the class and other classes will, if properly safeguarded against the dangers of social motivation, make the task of learning to write more interesting to the child. Seventh, the child should see a record of his progress in order to pace himself.

Arithmetic

Introduction. Probably no subject in school meets with more opposition from the pupil than arithmetic. The situation is all the more serious because a knowledge of arithmetic is economically important. It is necessary for progress of any

[5] Brooks, F. D., "Time Assignment and Rate of Improvement in Handwriting." *J. Educ. Psy.*, 1919, Vol. 10, 350-354.

kind in scientific prediction, discovery, and invention. Mathematics is involved in bookkeeping and many other forms of clerical work; in managing one's business affairs; in any form of careful and permanent construction work, as in building bridges, roads and power plants; in all the descriptive and social sciences. In the descriptive sciences intricate mathematical processes are necessary in bringing electrical energy under control or in constructing light systems, in fact, wherever the direction, speed and balancing of forces are involved. It is used in making the apparatus for measuring defects in vision, and in many other medical pursuits, especially in calculating the intensity of bacteria populations in various media, and in analyzing the chemistry of the body. Everywhere, mathematics is the final source of appeal for accurate work. It is deplorable that, as a subject, it is unpopular and considered to be difficult; more deplorable still that school systems do not require more of it and make it sufficiently interesting to appeal to the average student. *It can be done, and the right kind of teacher has always been doing it.*

The Psychological Basis of Arithmetic. Learning arithmetic begins with the child's undifferentiated concept of number, size, magnitude, and quantity. Originally his quantitative world contains no idea of specific size, or quantitative value. His first differentiation is into *more* and *less,* a gross differentiation of a quantity-field or range. The first concrete idea of a specific number is that of '1'; it is the simplest. Then his quantity world, insofar as it has developed, is a multiplicity of '1's' of an indefinite number. The range beyond '1' is the 'many' to which words like 'two,' 'twenty,' and 'thousand' are at first equally applicable. The procedure of learning numbers, then, occurs in the usual direction, namely, that of going from the whole to its parts, the undifferentiated to the differentiated.

How Individual Numbers Acquire Their First Meaning. If the teacher assumes that the child learns arithmetic by means of a drill process in which 1 derives an isolated meaning of 1, 2 an isolated meaning of 2, and so on, she will never teach arithmetic. Moreover, *counting from 1 to 10 is not adding '1's' to one another.* Psychologically, it is the verbal expression of an expanding, quantitative idea. 1 is a small unit,

2 is a larger whole, 3 a still larger one, and so on. Each is a totality of a given magnitude. Just how large the last magnitude is and what the relative differences are between each one, are something which the child, at first, does not perceive. He understands that 'something is getting bigger' by something called 'one,' or 'each time there is more.' The sizes of the steps 1, 2, 3, 4, as compared with 2, 4, 6, 8 or 5, 10, 15, 20, are yet to be differentiated from the gross quantity-pattern that characterizes the child's *thinking* in regard to number.

The equality of the steps, and their relative sizes, are discovered only as the meanings of several numbers differentiate out, together, from this pre-existing idea of magnitude and range. Thus, when the child really understands the difference between 1 and 2 he also understands the difference between 2 and 3, and 3 and 4. If he cannot transpose up and down the quantity scale he has no adequate conception of any one of the steps. The grief that most pupils encounter in mathematics is due to feeble insight into these interrelationships of simple numbers. This insight need not be expressed in the abstract ways characteristic of the mathematician's reasoning. Remember the goldfish! Relations are perceived and used without labelling them; the laws of dynamics guarantee it, and it is up to the teacher to guarantee that the laws of dynamics are properly followed in the teaching of arithmetic.

Applying all of this to concrete situations, the child learns quantity through discovering it. He looks at one penny and then a group of pennies and discovers a difference between the groups and apprehends it vaguely at first as a difference in 'manyness.' He must learn to count the groups through the expanding whole method. He can count from one to two, first; then from one to three, then from one to four. Each counting process is a unit, a temporal configuration which, to mean anything at all at his stage, must commence at *one* each time, and go the limits of the pattern that are determined by his level of maturation.

Relativity of Number. The value of a number, therefore, is relative as well as absolute. In learning to count from one to ten, the child discovers the value of each number from its emerged position in the range. He is aided by *seeing* the

objects counted in their position in the range. The fourth object, for example, is farther along toward the right end of a row; the first is at one end, the tenth at the other. Each position derives its 'hereness' or 'thereness' through a differentiation process. The 'hereness' coincides with the 'this muchness' of the number. The child does not analyze his procedure in this way, but this is the way he does it. Eventually, then, a given number derives its meaning from its position in a whole. 4 is not only 4 but so much more than 3, so much more than 2, so much less than 5, so much less than 6. Just how much the difference is, must be discovered in the course of maturation, induced through the stimulation attending the use of the numbers.

These relations are not explicit; they are felt; taken for granted; *learned,* not necessarily said. And if they are not *learned* after the fashion already described in case of reading and spelling, they are not learned at all. They are learned as animals learn relations, namely, by responding to stimulus-patterns in relational ways. A proper recognition of this fact would mean a rewriting of our arithmetic texts and instructions for teachers. The way we have described is the way the self-educated person discovers number and its interrelationships; it is the fashion in which the concept of number and its use developed in the history of the race. It is the way children actually learn it. They follow, in other words, the law of segregation; progress is based on numerous transpositions.

Solving a Simple Difficulty. A second grade pupil was having difficulty with simple subtraction. A study of her errors showed that the number-range from 1 to 9 had not differentiated. She had not discovered that 2 was next to 1 in the range, that the distance between 3 and 1 was next in size, and that the distance between 9 and 1 was the greatest. She was, at first, just as likely to say that '9 take away 1' was 1 as she was to say 8. Similarly, the answer 5 was just as good as the answer 3 to the problem of '5 take away 2.' In order to differentiate the number-range her teacher said to her one day: "I am going to give you a lot of examples; now watch. There is a secret coming out." Then she gave her the following examples: 2 — 1, 3 — 2, 4 — 3, 5 — 4, 6 — 5, 7 — 6, and so on, in order.

Soon the child discovered that the answers were all 1's. "That's the secret," she exclaimed. Notice that each of the problems was different, yet they were all based on the same plan. This gave the child an opportunity to 'feel' or 'sense,' at first vaguely, the nearness of each number to the other in the range. Then the teacher gave her another series with the differences all 2; another with the differences all 3; another with the differences all 4. Then she changed the 'secret.' Now the first answer to a series of problems was 1, the second answer was 2, the third was 3, until the range had been exhausted. Then she reversed the series. The child was so interested in discovering hidden secrets that she worked with the teacher for two hours without becoming tired, and at the end of that time had discovered how to figure out answers for herself in more difficult problems with numbers above 9. This is precisely what is meant by making subject matter vital. The life of learning is discovery of plan; principles command an interest. In this case the expedient of permitting relationships to emerge in patterns resulted in a very rapid differentiation of the child's number range.

The Expansion of the Number Range. As the number range is expanded and the child confronts arrays from 1 to 100 the range is too long and, if divided into units of 1, too detailed, adequately to apprehend with jumps from the total range to individual units of 1. Man has recognized this difficulty in his invention of the verbal and written counting system by dividing the range into groups of equal size. There is the group of 10 from 1 to 10; it is repeated from 20 to 30, again from 30 to 40, and so on. There are groups of 10, and 10 groups of 1,000's, 10 groups of 10,000's, 10 groups of 100,000's, until we reach a million and beyond. The larger the group the larger the subgroups. All this came about as the thought processes of man, developing with respect to number, followed the law of least action. Every normal child, at a certain stage in his mental development, loves to play with these ranges, and the discovery of their systematic character is a delight.

The Grouping System. The grouping method of teaching number facilitates the evolution of relationships in the child's thinking. For example, a group of 10 can be divided into 10 subgroups, each of them equal, or into 2 groups of 5, or

5 groups of 2. Unless the child stays with this sort of process long enough to grasp the meaning of grouping he is not ready for the next step in the learning-expansion process. And needless to say, the teacher cannot adequately present the subject, who does not understand the logic of number herself. She must give to her pupils the simplest little problems that will bring out the early forms of configurational response to number-stimuli. Again it must be insisted that much of the grief children encounter is not due to the intrinsic difficulty of the subject or to stupidity on the part of the pupil, but to the associational psychology and 'machine' concepts that determine the teacher's idea of what arithmetic *is* and her methods of teaching it.

Arithmetic Through Measurement. The beginner is introduced to arithmetic effectively through simple processes of measurement. An object is measured and found to be so many inches long. When the total length is being considered, the individual unit, or inch, is subordinate. Then the child obtains the ideas of wholeness and sum. When various objects are measured and their total sizes thought about along with the numbers that symbolize their sizes, ideas of magnitude are differentiated the more readily. It is helpful, also, to make larger objects by putting smaller ones of the same size and form together, as in cube building, and in manipulating dominoes.

Adding and Subtracting. Adding and subtracting with the use of symbols, such as the plus and minus sign, should not be attempted until the *principles* of taking away and adding are understood through object-lessons. The use of symbols presupposes the apprehension of number relationships in considerable detail, and if their use is attempted before the relationships between different units of quantity have been grasped, the signs mean very little.

Transition from Object-Lessons to Written Work. The simple process of putting down on paper the example

$$2 + 2 = 4, \text{ or } \begin{array}{r} 2 \\ \underline{2} \\ 4 \end{array}$$

takes for granted a higher level of maturation than is ordinarily supposed to be necessary. Symbols stand for abstract meanings and even when the mechanics of using them is

reduced to its simplest terms the thought processes required to use them are very abstract. Usually the jump from counting and object-lessons to written work is taken too abruptly. The maturation processes of the pupil are not properly paced. This difficulty arises at every step of the teaching process, especially when problems of carrying over, fractions, long division, decimals and interest, are introduced. The method of grouping objects should be employed in making these transitions, and maintained until the meaning of the grouping of written symbols is plain.

The principle of transposition should be employed more effectively. Thus, in learning what the example in addition means as a grouping of symbols, objects can be grouped, counted, and the example checked that way. If more children understood in the beginning, through methods of this sort, that numbers stand for groups of objects, or groups of conveniently selected units of measurement, each step in the maturation process would be easier.

Multiplying and Dividing: Fractions. The grouping method should introduce the child to processes of multiplying and dividing, the smallest groups taken first. Thus, 2 objects can be arranged into two groups of 1 each, 4 objects into two groups of 2 each, 6 objects into two groups of 3, or three groups of 2. The child learns that two groups of 2 make 4 or that 4 can be divided into two groups of 2. The relation of division to addition, and of multiplication to division, should be discovered before the pupil goes on.

Again, the pictorial method is helpful by making it clear that multiplying goes one way and dividing the other, and that multiplying is a short-cut way of adding and dividing a short-cut way of subtracting. The method of grouping and manipulating objects is again useful in introducing fractions, and at each step in the complication of fractions. For example, the problem is given of adding $\frac{1}{6}$ and $\frac{1}{4}$, fractions which must be reduced to a common denominator. The accompanying diagram (Fig. 50) illustrates how the common denominator is 12 and the $\frac{1}{6}$ becomes $\frac{2}{12}$ and the $\frac{1}{4}$, $\frac{3}{12}$, making $\frac{5}{12}$ths. This method provides the pupil with the mathematical whole of which four and six are parts.

Sources of Difficulty. Transposition and the law of segregation show how each number derives its meaning by being perceived in a great variety of relationships. One of the greatest faults in teaching arithmetic is in the improper selection of object-lessons that do not illustrate, *and in not selecting enough of them of different types.* The child who forgets a word is one who has not seen the word in a sufficiently large number of *different* sentences. The child who cannot manipulate a number in a given example, is one who has not seen this number

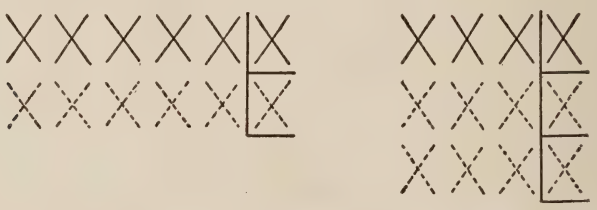

FIG. 50. SCHEMA SHOWING THE GROUPING METHOD OF TEACHING MIXED FRACTIONS.

The figures show how each denominator must be expanded until a common whole, divisible by each denominator, is reached, and how the one-sixth becomes two-twelfths and the one-fourth, three-twelfths.

function in a sufficiently large variety of illustrations at the same level of difficulty. Principles are only understood by seeing them operate in a variety of situations, not as nearly *alike* as possible but as *different as possible,* so long as the principle is not obscured. (Special case of maximum work.) The pupil fails, therefore, because he cannot transpose and hence know what to do with a number when he sees it in a *new* context. He is not familiar enough with a range of mathematical wholes which gives to the number its property or function in the given example. The conditions for the law of segregation have not been satisfied.

Examples of Pacing and Transposition. The following is an application of pacing and transposition to the initial teaching of fractions. First, by the graphic method show the class what ½, ⅓, ⅔ and so on, are. Then raise the question of how fractions are added. *Step one:* Did you ever stop to think why you could add 2 and 1 and get 3? It is because 2 equals 2 ones and 1 equals 1 one; that is, the 2 equals two parts

and the 1 equals one part, and all the parts are the same size. You can add 3 and 4 and obtain 7 because 3 ones and 4 ones are 7 ones; there are 7 things, 7 parts all the same size. If they were not of the same size you could not add them. Now let's take ½ (with help of graphs, say of a pie) and another ½. The two halves of anything are the same size; they can be added. What would ½ and ½ be? (Easily demonstrated to be 1.) Similarly ⅓ can be added to ⅓, or ⅓ to ⅔. (Transpose to fourths, fifths, and sixths.) But now suppose we had ⅓ and ½. ½ is bigger than ⅓. These parts are not the same size. What would ½ plus ⅓ be? No, they cannot be added just as they are. But if two parts of the same size can be added, what must we do to the ½ and the ⅓ in order to add them? Make them into parts that some way do have the same size.

Step two. Let's see how this is done. (Draw a circle, dividing it into thirds. Draw beside it another circle, divided into halves.) Can anyone think of a way to divide both these circles into parts so that we will have a ½ and a ⅓ and yet have parts that are the same size? What would happen if we divided one of these thirds into two parts? Then the next one? Can anyone tell me when I finish dividing all the thirds how many parts we would have? Now look at the piece we started with, the ⅓ drawn with heavier lines. ⅓ is equal to what? Each third has how many parts? What is the size of these smaller parts? Yes, they are sixths. ⅓ is equal to how many 6ths? See now what we can do? We can add ⅓ and ⅚ by changing the ⅓ to ⅔. ⅔ and ⅚ are what? Just like adding ⅓ and ⅓, only the parts are smaller and there are more of them. ⅙. Right.

Now let's go to the other pie. What will we have to do to this one to find out how ½ and ⅓ can be added? (Try to get class to reason it out for themselves.) Suppose we divided each half into 2 parts; how many parts would we have in all? Four. We can't add these to thirds, can we, because fourths and thirds are not the same size? Can anyone see a way out? What if we divided each half into 3 parts? Can we do that? Then how many parts would we have in all? And would we still have halves in one case and thirds in the other? Now we

have it. We have parts all the same size. ⅓, we found, equalled ⅔ths; and now we discover that ½ equals ⅜ths. Now can we add? ⅜ and ⅔ are how many 6ths? Now let us check up on some of this. Suppose we had ⅔ and ⅔. What would be the answer? Two. Why wouldn't it be ⅘? Why wouldn't ⅜ and ⅔ be $\frac{5}{12}$? (Transpose to other fractions, slightly larger, then increase the jumps.)

Long division furnishes another excellent example where pacing and transposing are necessary if the material is to be understood by the pupil. Begin with a simple example, such as 4 into 8, written out long division fashion. Then give 4 into 88; then 4 into 888, explaining the value of putting down the first 8, subtracting and bringing down the other 8. Then an example like 4 into 52. Here the pupil can ordinarily see for himself the logic of bringing down the 2 to go with the left-over 1, thus making 12 into which 4 goes 3 times. Transpose to 4 into larger numbers. Now give examples like 8 into 16; 8 into 168; 8 into 1616; 8 into 176, 279, and so on.

The greatest difficulty in long division is guessing. This is because the number range is not sufficiently well differentiated by the time long division is started. In order to facilitate the solution of this problem, make numerous transpositions with small steps, thus acquainting the pupil with unfamiliar relationships in the number range. Thus: 16 into 3278. 16 into 32 is easy to guess. Now make it 16 into 3742, and 5480, approaching gradually the easy orientation point 6432. Repeat with other small divisors, gradually running up through the 20's to the 50's and 70's, with dividends at first easily divided by guess. Then make harder. Whenever the pupil meets with a difficulty stop at once and transpose to other problems which introduce the same difficulty, first in its simplest possible form, then in harder forms. The main difficulty in arithmetic of any sort is in making the jumps too abrupt.

Geometry. The more difficult branches of lower mathematics, like plane geometry, suffer from an inadequate understanding of the mental processes involved. Principally, this lack of understanding is the false idea that wholes are built from parts. It is harder to perceive the larger wholes, first, and therefore the temptation is to employ smaller ones and try to put

them together. This, once more, is fatal. No difficulty with the whole-to-the-part method is encountered if the first wholes employed are sufficiently simple and undifferentiated. Take the case of solid geometry. One great difficulty with the subject lies in the fact that the student attempts to build up forms from lines and spaces from planes. This is not the natural way in which mental processes take place, and of course the student will come to grief.

Before the problems of solid geometry can be understood, space must be understood. Textbook writers and teachers in geometry might well take suggestions from Professor Hood,[6] who has turned the tables in teaching descriptive geometry. He begins by introducing his students in engineering to simple space-wholes, *which are to be apprehended as wholes.* Then it is shown how a whole, say a cube, can be divided in various ways in various directions, emphasizing all the while how the divisions come from the whole and are not put together to make the whole. In the end the class understands the subject when, taught the other way, its grasp is meager and is acquired in spite of the method of presentation.

Relative Difficulty of Different Mathematical Operations. Numerous studies have been made, from a statistical standpoint, showing that some of the inadequacies in teaching and in writing textbooks in arithmetic hinge upon a failure to recognize the relative difficulty of different arithmetical operations. Adding 5 and 5, for example, is much easier than adding 4 and 5; 8 plus 5 is a relatively difficult operation; 5 times 8 is much easier than 9 times 6. The difficulty is due to the relative position of each number with respect to orientation points in the number series. 5 times 8 is easy because 5 falls at an orientation point; it is half of the easy number, 10. The product, 40, falls at an orientation point in the range from 1 to 100. But in case of 9 and 6, the numbers fall in the vaguer places within the natural number groupings and 54 involves no definite orientation points in the 100-range. Studies point out that the more difficult operations should be used more frequently in actual examples. There is no reason, if a sufficient number

[6] Hood, G. J., *Geometry of Engineering Drawing; Descriptive Geometry by the Direct Method.* New York: McGraw-Hill, 1926.

of examples are given where the difficult operations appear in a sufficient number of relationships, why they could not be easily mastered. It is convenient, also, to spend more time on the operations that will be more frequently used in life than upon those which are seldom used. Here, however, the utilitarian motive may defeat itself if not cautiously employed, as we have already pointed out.

Guides to Teaching Arithmetic. The following simple suggestions to be observed by the teacher of arithmetic arise out of our previous discussion. First, she should use meaningful problems that fit the interests of the child. Ready-made courses must always be modified to fit particular situations. Second, the teacher must always make full explanations of new problems. These explanations must be presented in language that the child can understand, but in obeyance of the simple systematic plan upon which number relationships are based at that particular level. Third, each new problem or operation should follow logically from the one that the child has already discovered, and the child must see this relationship before he goes on. The child's development of insight must be paced. Fourth, problems must be definite and understandable to the child and must always be elaborately illustrated. The temptation is not to illustrate enough, or not to provide a sufficient *variety* of examples at a given level, in order to permit ease of the transposition processes upon which progress depends. Fifth, the child should not memorize the operations; he should learn by apprehending numbers in new relationships. Each step is a discovery of a new relation. Sixth, the teacher should ask questions about the problems to make sure that the child understands what he is doing. Seventh, making a story out of the problem gives the task more meaning and guarantees more interest on the part of the child. Legend and culture can be appealed to at each stage of the child's progress.

Illustrations of the Whole-to-Part Principle from Architecture. Design, in architecture, is ordinarily taught by the part-to-the-whole method. The student begins, for example, with one side of the top of a column and learns how to draw it. Then he takes the whole top. Then he learns to draw the body of the column and then puts on the top. Subsequently

he learns to draw a roof, the sides of a building, and any special part, like an 'L' or porch. Having mastered the 'elements' of architectural design, such as lines, curves, angles and parts of structures, he then tries to draw a building. *But he fails!* He does not know the character of the whole which determines the value of the parts. *This whole is the building as a balanced unit, having proper proportions.* He does not learn the principles of balance and harmony as they pertain to the building by beginning with the parts. Between themselves, outside the whole, the parts have no harmony or balance. Consequently, what is he obliged to do? After he has spent all this time on the so-called elements (which, as a matter of fact, he understands only imperfectly) he must go back to the beginning, to fundamentals, and start all over again, and *discover what beauty and proportion are.* He has not learned to observe the field properties of the architectural unit which he must construct.

The newer way of teaching architecture applies the laws of dynamics directly. Instead of saying: "Draw me the top of this column," the instructor says, "Draw me a shed." The student learns, by studying a complete architectural whole, what is meant by unity, proportion and perspective. Then the course follows the law of the expanding, differentiating whole. The next instructions are, typically, "Now put some columns on the shed." Under these conditions the student must not only discover how to draw a column by itself, correctly proportioned, but how to make it the right size and of the right proportion to *fit* the unit to which it belongs. Then the instructions are given: "Put in your windows and doors; put on the porch." By this time the student has some chance to accomplish his task in artistic fashion because he already has the building as a whole to guide him, with its general properties of balance and harmony. Finally, he is instructed: "Put in the decorations," and the decorations are introduced to *fit the building.* An architectural unit has been expanding and differentiating under the law of unity; the parts fit because they have derived their properties from the whole. Sitting down to draw a mass of parts and putting them together is a task as impossible as it is illogical. Of course, in making a design of any building, there

is a drawing and redrawing of the parts in different relations to each other. Size, form and position must be varied until just the right effect is obtained; but it is done under the law of field genesis where each part ultimately differentiates from the total unit, balanced or integrated with all the other parts. If one part, say the column, is *too large* it throws the whole building off balance; it destroys the harmony of the whole, also, if it is not in the right *place*. Thus, each must be drawn relative to the others. The basic principles of drawing are, therefore, the same as the principles of perception, and of motor co-ordination, and of learning, of reading, writing, and of mathematics.[7]

Principles Applied to Teaching Harmony and Melody. Harmony and melody have always been a bugbear to students in schools of music. As ordinarily taught, the student must begin with 'elements' that, as anywhere else, do not exist. They are artifacts. First to be mastered are the mechanics of musical writing: the staff, clef, kinds of notes, rests and measures. There are the mathematical relationships existing between the notes of the scale and between the harmonics or overtones of a given tone. There is the problem of consonance and dissonance. Then there are different kinds of intervals between notes, like the second, third, fourth, fifth, seventh and octave. There are the various keys in which music is played, C, D, F, G, and many others; there are the minor and major groups of keys; and one part, two part, three part and four part music. These are the so-called 'elements.' But when the mechanics of all this are studied the student has *no idea of harmony and melody, no conception of musical proportion and beauty.* The whole that is more than the sum of its parts has not been discovered, or constructed. The student must go back and begin with simple music again and, for himself, study musical *form.* This can be done much better by means of the procedures with which we are familiar. Simple melodies and successions of chords are constructed that tell a simple musical story, and have unity and beauty as simple, musically balanced wholes. The *mechanics*

[7] The authors are indebted to Professor George Beal of the University of Kansas for this information relative to the teaching of architecture. Professor Beal is a pioneer in the modern method of teaching architectural design, as Professor Hood, previously mentioned, is a pioneer in the teaching of descriptive geometry by the expanding whole-part procedure.

of composition are learned *as* the problem is expanded and differentiated. Then each note, interval, rest, succession of fast notes, and each contrast effect, is introduced in terms of the balanced whole.

Very likely in writing music the finished product does not resemble the original, any more than the final drawing of a building resembles the rough original sketch, or the polished and elaborated story resembles the first draft. Nevertheless, the correct procedure has been followed. In the beginning, there was a main idea, theme, or plan which contained unity. Undifferentiated though it was, it possessed the aspect of completeness. Then it was expanded and the parts modified here and there to fit each other in the whole. This is the history of every creative act and every learning process, where art, science, language, thinking, or muscular skill are involved.

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CHAPTER XXVI

NEW PROCEDURES IN EDUCATION

Educational Measurement

Educational Tests. With school populations continuously becoming larger and with an increased economic necessity for efficiency in teaching methods, there has developed in recent years a widespread use of standardized statistical procedures in connection with methods of instruction. These procedures have aimed to introduce efficiency in the following ways: (1) by determining as closely as possible how much the average pupil can be expected to assimilate in a given subject in the course of a term or year; (2) by measuring the efficiency of different methods of instruction in terms of class and individual output, modes of presentation of subject matter, types of motivation, distribution of work periods, length of assignments, and socialized instruction; (3) by ascertaining where, in a given subject matter, most of the children make slower progress or make the greatest number of mistakes; (4) by ascertaining who are the good and the poor teachers in terms of pupil achievement; (5) by eliminating the personal individual differences in devising, in correcting and in grading examinations. The literature in the field of educational tests is voluminous and a great many suggestions have come from it that have reduced effort on the part of the child and teacher, alike; have increased the speed with which children master the subject matter, and made the school system more efficient and economical of expense, generally.

These tests have had specific values for the student. They (1) inform pupils of their achievement; (2) function as incentives to study; (3) promote competition and pacing. They have aided in the conduct of the school system by (a) helping to determine promotions and graduation; (b) by becoming one

basis for credits and honors; (c) by enabling the teacher to predict in advance what the pupil will probably achieve during the next term or, within limits, in the following years.

Achievement and Educational Quotients. Convenient methods have been devised for the measurement of a pupil's status with respect to the average performance of a large group of pupils in a given subject. If a pupil is below the average for his group it is a sign that something should be done to ascertain the cause of the trouble. It may be in his I.Q., or it may be in his interest, or it may be in poor instruction. It is possible that he has not discovered the fundamentals of his subject, although he has the requisite intelligence to do so. This frequently happens. Mental processes are very complex and the same type of explanation of a given problem may result in an understanding by one pupil and not by another of the same general ability.

The score which a pupil makes on a given arithmetic test, based on the same plan as a graded intelligence test, like the Stanford-Binet, becomes his Educational Age, E.A., that corresponds to his Mental Age. When this score or Educational Age is divided by the pupil's Chronological Age, an Educational Quotient is obtained. His Educational Quotient (E.Q.) is analogous to his I.Q. and will be 100 if he is average. The Educational Quotient is valuable in many ways. For example, a pupil, 10 years old, obtains the same score in arithmetic as the average of an eleven-year-old group. Then, if his score is divided into the average score or norm of the eleven-year-olds a value is obtained that is 110. This is the pupil's Educational Quotient. It means that he is one year accelerated or ahead of the average for his age in arithmetic. The E.Q. merely compares this pupil with others. It is possible to compare him with himself and to ascertain whether his E.Q. is what it should be in accordance with his I.Q. or his Mental Age. Suppose this pupil has a Mental Age of 12. In this case he should be mastering the arithmetic and other subjects that the average twelve-year-old is doing. The procedure of calculating the extent of this discrepancy between his E.A. and Mental Age is to find an Accomplishment Quotient, by dividing his E.Q. by his I.Q., that is, E.A. by his M.A. His E.A., represented by points, let

us say, is 132 (assuming that the arithmetic test is based on the same plan as the Stanford-Binet intelligence test where there are twelve points for each year of Chronological Age). We know that his M.A., being twelve, is represented by the score 144. Dividing the E.A. by the M.A. the A.Q. is obtained. This is 92. Therefore, the pupil is not working *at par* by the difference between 92 and 100.

The Accomplishment Quotient holds the factor of intelligence constant because, in accordance with the method of calculation, if the pupil achieves a maximum according to his I.Q., his rating by the A.Q. will never fall below 100, and it makes no difference what his I.Q. is. By holding the I.Q. constant in this way, it can be determined whether pupils of different I.Q.'s are working at their maximum. For example, a ten-year-old has an M.A. of nine instead of twelve. He makes a score in arithmetic of 108, the same as his M.A. score, which gives him an E.A. of 108. Calculating as before to ascertain the A.Q. we obtain 100. The second pupil, therefore, is doing better in proportion to his I.Q. than the first.

The Standardized Scale. Educational Scales, built on the general plan of a Mental Age Scale, have been constructed for various school subjects: reading, writing, arithmetic, spelling, geography, and others. In reading, for example, there are the Fordyce Scale for Measuring Achievements in Reading; the Courtis Silent Reading Tests; the Monroe Standardized Silent Reading Tests; Haggerty Silent Reading Scales; Thorndike-McCall Reading Scales and the Gray Silent Reading Test. Some of these emphasize one factor, some another, in reading, as speed *versus* comprehension. In spelling there are, as types, the Ayers Spelling Scale, the Buckingham Extension of the Scale, and the Iowa Spelling Scales. In handwriting there are the Thorndike, Ayers and Freeman Scales; in arithmetic there are the Courtis and Iowa Tests, and others.

The Diagnostic Test. In addition to a long list of scales there is even a greater number of Diagnostic Tests in most of the school subjects, whose use brings to light particular types of difficulties encountered by the pupil. The merit of these tests lies in the fact that an effort has been made to construct them on a logical basis, that is, to determine where the

reasoning processes of the pupil are at fault. But the motive for the plan on which most of these tests has been based is, unfortunately, *the conception of skills* (a mechanistic conception) so that the tests are generally in need of revision before diagnostic work will reach a high level of proficiency. Nevertheless, these tests have been of great value in school-situations and extensive remedial work with the individual pupil has been done on the basis of the test results. It is impossible without the aid of such tests for any teacher with thirty or forty pupils, to discover all the difficulties which each individual encounters in his work. Moreover, without their aid, it would be difficult to ascertain the exact nature of the difficulty even if, by more general inspection of the pupil's work, it had been discovered. The tests save time by directing the teacher to a relatively specific difficulty. It still remains true, however, that the cues obtained from such tests will not lead to an uncovering of the difficulty in every case, because the tests have been constructed with a mechanistic bias relative to the nature of the child's mental processes in the subject matter concerned.

The New Type Examination: Ruch. Another recent development in Education is an 'improvement' of examinations. Many researches have shown that teachers' estimates of answers on the essay type of examination vary over a wide range. Ruch [1] sent three history papers, taken from a seventh-grade class, to 115 teachers who graded each paper on a scale of 100. The range of scores given one paper was 70 to 100, for another it was 45 to 90, and for the third it was 25 to 85! In another investigation it was found that the same English papers were graded from 64 to 98, geometry papers from 29 to 92, and history papers from 43 to 90.

Not only are teachers' estimates of answers very unreliable in the ordinary type of examination, but the examinations themselves may not be a fair measure of the student's knowledge. This is because the selection of the material is not, ordinarily, standardized. An examination that passes one group of pupils may be intrinsically easier than another examination that will not pass a number of pupils. The College Entrance Examina-

[1] Ruch, G. M., *The Improvement of the Written Examination.* Chicago: Scott, Foresman, 1924, 56-62.

tion Board, in 1921, gave an examination which, according to Wood,[2] would have passed 1279 of 3000 possible failures and would have failed 1279 of 3000 possible passers, if another examination like it had been given. This is because the tests were not constructed on the basis of their statistical reliability. Pupils are promoted and failed on the basis of examinations. In justice to them the type of examination should be reliable and not fail them one time when another examination equivalent to it would have passed them. And to pass a pupil with an examination on the assumption that he is prepared to go on, when an equivalent examination would, presumably, have shown him unprepared, is another injustice.

Ruch and Stoddard[3] have summarized the faults of the ordinary essay examination as follows: (1) An examination has relatively few items; therefore the chances that another set of items of small number will be of equal difficulty is relatively slight. Moreover, because the items are few the chance errors of judgment on the part of the reader are magnified. (2) Even when the same examination is read a second time by the same instructor, after having forgotten the original mark, there is chance for a serious discrepancy. (3) The essay type of examination is unfair because it examines the pupil over an insufficiently wide range of the subject matter. (4) When two such examinations are constructed and given to the same class, the results, pupil by pupil, will not be the same and the pupils will not be arranged in exactly the same order of rank from poorest to best.

In order to offset these difficulties in the educational system it is possible to devise objective types of examinations which demand less personal judgment on the part of the teacher. These examinations test the pupil over a much wider range of the subject matter, and can be so constructed as to be far more reliable statistically.

The New Type Examination: Advantages. The objective examination may be made on a great variety of lines. For example, there is the true-false question, like, Texas is larger

[2] Wood, B. D., *Measurement in Higher Education.* Yonkers: World Book Co., 1923, 124-126.

[3] Ruch, G. M., and Stoddard, G. D., *Tests and Measurements in High School Instruction.* Yonkers: World Book Co., 1927.

than Maine . . . True? . . . False? There is the Multiple-Choice Test, such as can be found in Chapter XIV; there is the Completion Test such as Water contains Hydrogen and ——; the Matching Test which covers a great variety of relationships to be perceived, such as cause and effect. In one column there is written a list of causes having to do with effects and in an opposite column the causes are listed, but *in mixed order.* The student is to connect the member of one column with its appropriate partner in the other. There is the convenient Rank Order Test in which a list of objects is to be ranked in order of their size, or in terms of any property or principle that progressively runs through the list. Others are the Analogies Test, the Similarities and Opposites Test; and the Cross-out Test, where a list of objects of the same class is presented with one in addition which does not belong to the list. The advantages of these tests, among others, are as follows: (1) they can be scored more objectively than the essay type of test; (2) various forms can be constructed of approximate difficulty as determined by preliminary statistical methods; (3) they can be scored quickly; (4) they are more comprehensive in the sense that they cover a wider range of detail in the subject; (5) they encourage the pupil to think precisely.

On the other hand they have their disadvantages. In fact, final judgment as to the relative merits of the two types of examination waits after all upon the purpose of an examination. When all is said and done, examinations are a tradition! Leading up to a discussion of this problem, because it is one which is of great importance for Education, consider the disadvantages of the objective test.

Disadvantages of the Objective Test: A Measure of Factual Knowledge Only. First, the objective test places a premium upon *one type of knowledge,* the factual. While it is not impossible to construct such a test and still to some extent emphasize reasoning, it is difficult, and teachers seldom take the trouble. They follow the line of least action and construct the test from items that can be memorized. In fact most teachers have memorized the subject matter they teach; they have not really learned or mastered even the fundamentals. Facts, after all, are of no value unless the pupil knows *why* they are facts

and can use them in the right place and at the right time. This depends upon *reasoning,* whether the subject matter be easy or hard, simple or complex. One cannot reason without facts but the memorization of facts does not promote reasoning or the mastery of the subject matter. Indeed, one cannot state a fact without making some kind of an assumption relative to a reasoning process or theory, because facts derive their significance from hidden principles. Of what final good is it, for example, to know that at one particular year the price of wheat is 27 cents a bushel? That is a fact. The farmer, however, wants to know *why* he cannot obtain more when it costs 60 cents a bushel to raise the wheat. The fact of 27 cents has significance *only* in light of some total situation, *and this situation is the condition of the world market.* The whole determines the properties of its parts. Knowing the laws of the whole one knows what must be done if the wheat price is to be raised. A fact has no meaning or importance by itself.

Inconsistency with the Laws of Learning. Second, the objective examination prohibits the pupil from thinking *creatively.* We have seen, all along, that *learning is the making of discoveries;* the pupil who does not think creatively does not *really learn;* he memorizes in order to pass an examination, to obtain a grade, and to pass on. Large numbers of pupils continue this process throughout their educational career and when they are through they actually *know* very little. An indeterminate amount of time, energy and money spent on them is wasted. If learning is creative thinking, the products of creative thinking should be the measure of his learning. From this standpoint, a project conceived and carried out by himself to a successful end should be his examination; then he should defend what he has done. Naturally such a method of examining would be expensive. But are we basing our educational system upon an absolute economy when brain power is the objective?

A glance at the situation as a whole proves that *pupils would rather not memorize. Universally they prefer to learn, all the way from the grades to the university.* Yet we make them memorize, through a false conception of the learning process. It is said that pupils cannot reason until they have the facts; consequently facts are presented first. This is the false part-to-

whole procedure. It refuses to recognize the truth about mental functions, namely, that even to a child, facts are meaningless and unintelligible unless they are given under the laws of a hidden plan. When thus presented the facts have value and significance for the child; they stand up under the power of the whole which gives them meaning; they come to consciousness with no effort at recall, suggested only by the stimulus and a desire to use the fact. This is what pupils demand at every age. All down the line they protest. Any protest, based upon a desire, underneath, to learn, is a sign that the natural laws of learning are not being followed. They are followed when the facts mean enough to the student to use, discuss, exclaim about, fight over, ask for more, progress from of his own accord, or become thankful for at a later date. All this requires creative work continuously from the earliest years, and to the extent that there is any sheer memorizing, there is waste. One never learns by memorizing and repeating, and the student knows this where the instructor fails to know it. There are times when the child is father to the man! It is a question, therefore, whether we want the objective examination no matter how reliable it is statistically. One can work out any system of facts, like ways and means of selling bootleg whisky, on the basis of statistical reliability, but does that justify the facts?

Third, one of the most valuable sources of motivation already mentioned, but worth reiterating, is to promote criticism and argumentation. The pupil likes to say what *he* thinks. When the group does not subdue him, this is what he is always doing. *His own* reactions *are* his creative thinking, and show how much he is learning. The objective test gives the pupil no chance to express *himself* in the subject matter. One *must* do this if he is interested. Learning is never a mechanical process of listening to facts and giving them back again. To the extent methods compel this procedure, real learning does not take place.

Learning During an Examination. New types of objective examinations have recently been invented where the pupil learns whether or not his answers are correct as he takes the test. At the same time, the test tells the examiner how many times the pupil tried before he arrived at the correct answer. An objective test is presented on one side of a folder and al-

ternative answers are numbered. On the opposite side of the folder are rows of numbered dots corresponding to the numbers of the alternative answers. Beneath are three layers, two of paper, with a stiff cardboard between them. The pupil is provided with a punch. He looks at a given question, decides what answer to give it and punches the corresponding number on the other side of the folder. If his answer is correct his punch goes through the first layer beneath, leaving a mark, then through a hole in the cardboard to the second layer of paper, where it also leaves a mark. The holes in the cardboard correspond with the correct answers so that when the punch fails to go clear through he knows that he has not answered the question correctly. In this case, he tries again until he makes a correct response. The examiner knows from the number of marks on the first layer of paper how many questions were answered incorrectly the first time and how many 'guesses' were required before the correct answer was found. (John Peterson.)

The Problem of Cheating. The prevalence of cheating in examinations in high schools and universities casts a serious reflection upon our educational system and is a problem which, unfortunately, many educators are unwilling to face. It is proof of a serious defect in the system, but one hates to admit that the system is faulty when it is one of his own construction, or one with which he has identified himself! Prospective teachers owe it to the educational system, to the student and to the success of their own teaching to consider the matter from all angles, *as a psychological problem.* The causes of cheating are obvious. It is a sign that the student is working for an ulterior motive and not for the sake of learning when, in reality, he attends school in order to learn. The cause of the cheating, therefore, is a reward that does not represent achievement. Under the laws of human nature an ulterior reward cannot measure or represent achievement for the achievement is inevitably its own reward. To the extent that grades are effective they are a reward for another achievement, that of having secured social approval often without mastery of the subject matter. If no one knew about a person's grade it would not be worth working for, whereas mastering a given subject is its own reward whether anyone knows it or not. The greatest minds of all

ages have placed achievement first and social approval second. All minds obey the same principle whether the achievements be modest or great, learning to spell or discovering a planet. The learning achieved, the learner, until spoiled, imparts his information from a demand that others share the interest and value in the discovery.

The grading system, therefore, places a premium upon *hypocrisy* and the acceptance of something for nothing. It cannot remain as a factor in our educational system for it is causing the system to defeat its own purpose. And as the classroom becomes more crowded, teachers more and more overworked, and more and more emphasis is placed upon the sheer memory of the student, the situation is gradually becoming worse. When the atmosphere of cheating once permeates an institution the student, honest when he reaches the institution, is at a serious disadvantage. With others around him obtaining grades without mastering the subject he feels that his achievement is not worth very much and sooner or later accepts the attitude of "What's the use." Moreover, social pressure, whether consciously brought to bear or not, has its effect. While in Rome he does as the Romans do.

Worse yet, the methods and lore of students in the higher institutions are gradually creeping into the lower ones, where, at least, they are in proximity to each other. The high school student emulates the college student; the junior high school student emulates the senior high school student, and so on down the line. And finally, the problem is aggravated by increasing masses of students at all ages in the school system. This means that the scattering of 'ability' at each level is wider, especially in the direction of the lower end. The presence of increased numbers of dull students exaggerates the cheating problem. It creates additional difficulties, as well, because the lower grade student has a greater effect on the higher grade student than *vice versa.*

The laws of the moral life are natural laws. Where there is conflict with moral principles, or in this case dishonesty, the laws have been misapplied. The cause must be removed. It is a psychological problem not alone of motivation but of correct methods of instruction, based on the laws of human nature.

Where there is cheating there is the lack of the will to learn, and where there is no will to learn there is no learning. The educational psychologist is as obligated to solve this problem as he is to determine whether one should learn 'by wholes or by parts' for, after all, he must control the *will* as much as the mechanical technique of distributing subject matter.

Student-Centered Schools

The New Purpose in Education. These are only a few of the problems which modern trends in Education are attempting to solve on a psychological basis. To study these trends seriously is the obligation of everyone who is preparing to teach at whatever level in the educational curriculum he intends to work. Sooner or later some of the students who are taking Educational Psychology will be high school principals, superintendents, and leaders in Education. Problems in administration ultimately trace back to psychology for the organization of the curriculum and the expenditure of budgets depends upon what Education is for, and what Education is for depends upon the laws of human nature. We have raised the problem of examinations and cheating in order to introduce questions about which the prospective educator *must be thinking.* When the facts are faced it is doubtful whether Education is adequately accomplishing its aim, *that of teaching people how to live.*

Believing that Education is not adequate because it is not based on sound psychology, many private schools have sprung up over the country, which are attempting to eliminate the obvious evils of mass-and-mechanized Education. This movement is not a repudiation of Democracy in Education; it is an effort, in a small way, to save it from the law of diminishing returns. These are schools which are based upon the principle which has been emphasized throughout this text: Learning through creative response. Do not make the mistake of assuming that ultimately, learning is accomplished *by* creative response. This makes one the cause of the other. They are not two things; they are one. Even if one is defined as the process through which the other finds expression, they are, after all, synonyms.

Numerous books have been written on the new type of

school. It may be called, at the elementary level, the "Child-Centered School" for it emphasizes the individual rather than the group. It emphasizes creative work based upon the inventive character of the learning process, not upon memory, which, taken alone, is mechanical. It emphasizes the repeated confronting of problem-situations, not drill; the recognition that learning depends on personality and the will, not upon association.

Activity Hours. Needless to say, as much emphasis as possible is placed upon the individual in the public school, especially in the kindergarten, and by Activity Hours introduced into the school program in the grades. The classroom situation is permitted informality and the pupils engage in simple, creative, laboratory work. This is expensive, for much equipment is required, but it is *necessary*. For example, geography is studied through the construction of mountains and river beds in molding material, through the examination of specimens, or through spontaneous reading in new books where there are many interesting illustrations, or through trips to an auditorium for a moving picture. History is studied through putting on a brief pageant, made to order, or through a dramatization of a simple historical event, involving brief speeches. These are signs of an awakening in public systems of Education. They are recognitions of the laws of human nature even by those who are uninformed concerning the scientific reasons why the method is effective.

Direction in Higher Education. There is a modern trend in higher Education indicative of the changing attitude toward Education in general. As junior colleges have grown up in connection with larger high schools, relatively fewer freshmen are entering the universities and relatively more juniors. The character of work in the universities, therefore, is slowly changing toward an emphasis upon advanced study. With this emphasis there is greater opportunity in the university for methods to fit the real nature of the learning process. There is a growing tendency to permit students, earlier than formerly, to engage in individual, creative work of the character that is done in graduate schools.

But this movement even in universities is held back by a

false conception of how learning takes place. There is the 'fear' on the part of many university instructors that students are not 'ready' to engage upon projects because they have not first been drilled sufficiently. The new movement is regarded as a breaking down of protective standards, so strong is the belief that formal standards produce learning. Every successful case, 'slipped over' on the system is explained away as 'exceptional!' On the contrary, where project work can be done under the proper inspiration and guidance that comes with personal contacts with enthusiastic instructors, the 'fears' are ungrounded, whether the case be one of a bright student or dull! Why, simply because the dull follow the laws of the bright in simpler situations; they, too, must learn in the course of making discoveries for themselves, and of *participating* in the solution of problems. Indeed, facts handed to *them* on a platter take *less* effect than in case of the superior student. All this holds from the kindergarten up. The graduate student learns no differently from the three-year-old, and the three-year-old must learn at his own level and with his own equipment, the way the graduate student learns.

Universities are, therefore, being transformed into institutions that are 'Student-Centered.' Formal rules and regulations are being abandoned and the student is thrown more on his own, even in case of regular class work, as is now being tried at Chicago. In this movement it is the purpose not to give compulsory examinations except at widely scattered intervals and to make the examinations comprehensive rather than specialized, rational rather than memorial. In certain institutions, as Johns Hopkins, the lower college years are abandoned. In other places, as at Yale and Harvard, the plan is developing of splitting the institution into small colleges where life is relatively informal and more personal contact is available with the instructor. Here large classes are avoided and the entire curriculum informalized.

Future Needs in the Light of Psychology

Relation of Administration to Psychology. In recent times the problems of Administration have been seen from the

angle of financial economy, methods of obtaining and spending money to the best advantage, bookkeeping, organization of the school, construction of buildings and playgrounds. No one of these problems, certainly, is unworthy of most careful and painstaking consideration and research. Nevertheless, the tendency to specialize leads to a consideration of problems in their most limited aspects, out of relation to larger and more basic issues that, of necessity, must determine the fundamental administrative plan. The left hand in Education, Administration, knows not what the right hand, Psychology, is doing.

Testing and Standardization. The facts point to a serious situation. Researches in large numbers in Administration are carried out with little attempt to inspect the psychological assumptions implicitly made before the research is undertaken. These assumptions determine the problem, the method of investigation, and the interpretation of results. One need only to consider the testing movement to find a glaring example. The testing program, devoted to individual examinations and dedicated to the problem of the pupil's individual rights and needs, lost its savor of idealism, and became a mass method for oiling a machine. Instead of a means of understanding the individual better, it became a means of preserving an institution whose life was based on standardization. The spirit and emphasis changed from the individual to the group and the maintenance of group standards and levels became the goal. The purpose was to fit the child to the standard, and to the method, not the method to the child.

Meanwhile, thousands of investigations on testing had been made, for administrative purposes, only a few of which have solved a pressing educational problem. Instead of facing the question, Does mass education pay? Administration asked, How can we make mass education better? In the light of human nature does standardization pay? Is it achieving the aim of Education to train youth how to live the remainder of their lives?

The Psychological Answer to Standardization. What are the facts of standardization? They are that a pupil should at a certain time and at a certain age know just so much and be able to pass a standardized examination; that before he can

obtain a given certificate or diploma, so many examinations, so many credits and so many years of work, no more and no less, must have accumulated. But why should Education be standardized? Why should pupils be pushed, like so many bushels of corn, through a grist-mill, over highly mechanized channels? There must be some uniformity in procedure, of course, but are these questions adequately being faced? Is standardization the correct procedure, after all, in light of the fact that what is learned is only that which is discovered, and what is achieved is only that which is invented or created? The answer is "No," and is found in our present efforts to eliminate from Education as much standardization and as many of the formalities as possible. But the great movements in Education have not come about primarily as a result of systematic investigations; they have resulted from the penetrating insight into human life and its needs, on the part of exceptional leaders. One good mind is worth more to Education than a thousand investigations where assumptions are not inspected and fundamental issues are not faced.

Selection of the Teacher. It is the personality of the teacher by means of which the evil effects of mass education must be reduced. We have seen that learning is directed growth, the expansion of a personality that controls the process of learning from within. But it is growth of a human being dependent upon motivation through personality contact and the culture which the personality in the teacher derives from the culture of the race. There are teachers who brighten the schoolroom with their personality and enthusiasm, and who inspire the pupil with the romantic and exciting color of the information which they divulge. They know life, and live it. They see and understand discovery and creation. They are the doorways into a wondrous world. It is from these that the pupil learns. There are teachers whose rooms are as gloomy as a tomb; teachers who rock the atmosphere with the cyclones of an erratic temperament. There are others whose indifference chills and subdues spontaneity; those whose superciliousness makes her pupils stiffen with bridled protest and contempt; those against whose fawning manner even a child revolts; and those whose sheer emptiness casts a pall upon the schoolroom.

No teacher enjoys the feeling that her personality is under surveillance, but if she teaches she must face the conditions that determine at once her success and the fact whether her pupils learn. These are first questions, for the learning of the child is subordinate to his attitude of mind and he responds to the personality before him as a small body in a vast field of force responds to the invisible pressures around it. The most intangible, least measurable and least known forces in nature are among the most potent, and personality is one of these. No student passes through the educational system without the stamp of some teacher upon him. Thousands are inspired to careers of particular achievement by their teachers, alone; thousands lose the benefits of school because of treatment from their teachers. Unnumbered mental lives suffer septic operations and endure the ravages of permanent infection, through sheer inefficiency and stupidity of teaching. The teacher is the physician of maturative processes, and there is no redress from wounds that are sewed up wrong.

Grades, hours of credit, these are most meticulously inspected, but the sterilized insight, the unfulfilled demands and the disillusionment! Who knows about them? Not the system. It is not organized to care. Personalities retard mental growth; they raise intelligence as measured by test scores from the lower portions of a given range to the highest. It is being done every day. It is the most pressing need of present Education, a more adequate training and selection of teachers. And why are not more of the cream of college youth, with the personalities to undertake this vital work, taught of its importance, and shown the opportunity? Ask almost any better student of today if he is planning to enter Education and his reply is, "I should say not!" The educational dryness, dullness, mechanical deadness of the mill, so fresh in his mind from just having passed through it, is too much. The intelligence ratings of a Teachers College population are not encouraging! The financial outlook for the teacher is anything but tempting to the individual with ambition and personality. He has so little respect for Education when he is done that, when he comes face to face with better opportunity elsewhere, the possibilities for him, in returning from whence he came to make it better, are too remote and im-

practical to consider. When a system puts through hundreds of thousands of individuals, most of them shouting with gladness to have left it, something is wrong. It is not living. Achievement leaves a memory mixed with pride and joy; the feeling of something unfinished that demands a further completion. Learning is, by nature, achievement; but where is the feeling of something unfinished? Where are those who must go back to the field of Education with the insistent demand to finish, to complete and find a further demand? Why the many thousands who go on from the high school with no demand to reach a real intellectual goal or to prepare themselves, seriously, for the task of solving the major problems of the race?

The Problem of Practicality in Education. Workers in Education are prone to misjudge what is practical in the schoolroom, because of an inveterate mechanistic bias. The most important and practical things are those which are the least tangible and the least measurable—matters pertaining to social conditioning, personality, the control of wholes over their parts, insight, maturation, discovery, goals, detection of principles and plans, the understanding of relations as well as things, idealism made practical in life-situations, and culture. Education represents too much specialized skill as compared with general insight. The 'skills' we are producing cannot be transposed from one field of activity to another or from limited and concrete situations to general, less tangible, but more important, ones. *'Skills' are like 'reflexes'; they will not integrate; they are the end products or consequences, not the explanatory 'elements' of learning.* Students are not well educated because Education does not follow the law of field genesis. There is not enough knowledge of life as a whole. Education is making circus animals of its pupils by forcing them mechanically to conform, and, like that of the circus animal, their training is of little value to them in their natural environment. Education is not as practical as it is said to be when it is not training its pupils to keep pace with the problems of the world.

It is obvious that children have learned under methods promoted by mechanistic, bond psychology, but equally as obvious that they have learned in spite of, not because of, the psycho-

logical assumptions employed in accounting for the results. This is easy to explain. We have not been doing that which we said, under association psychology, we were doing. The error has been one of oversimplification, of seeing parts before wholes. Education has sometimes applied the organismic method without knowing it. Thus the discovery of new principles validates many of the good intentions of the past; shows where they should be radically extended, and where many present evils should be eliminated.

Unsolved Problems: Preservation of Culture and Creativeness at All Ages. The little problems of eye-movements; which words are used most of a given three thousand; which are spelled most often incorrectly; which combination in the multiplication table is most missed; whether Henry VIII had six wives or nine; whether the *Maine* exploded or was sunk; whether the Missouri River rises in Montana or North Dakota; whether there are sixteen units instead of fifteen and a half; whether five per cent of students fail or ten—these sink to levels of insignificance in the face of more pressing needs. Are not the real problems: Why children fail to understand their reading and fail to remember words; why they never learn to spell at all; why they hate mathematics; what Henry VIII meant for millions of human lives; whether the Spanish War was justified; what the Missouri Valley means in terms of a world market, or as an evolutionary epoch in the history of a vast continent; whether units of any kind really represent four years of a developing mind, and whether students should be failed or not?

Is Education solving the problems of human beings, discouraged and deadened from within the system? Is it keeping alive the culture of the child and developing it until, when he matures, he understands the seriousness of lethargy at the polls, waste of natural resources, the consequences of a commercial age? Is it developing that human insight which will stamp out wholesale graft and crime, let alone refuse to indulge in it, solve racial and international problems; prevent economic depressions and World Wars? Is the youth, so prepared, capable of understanding and enjoying the best and permanent in human achievement, the literary, musical and artistic creations

of all ages, just those evidences of living which, in simpler form, he demanded from others and produced himself before his formal Education started? Can he now appreciate the philosophy of the maturer mind, that had its spontaneous counterpart, when a child, in his demand to know where the self dwelt within him and what kept the cycle going from seed to plant and plant to seed? Can he apprehend the momentous significance, even if but in a general way, of the change from Absolutism to Relativity, and the social and moral genius of a Christ or a Gandhi? Will he become interested in the higher problems of what life is all about and participate in the eternal effort to solve them? Or, will he live with no foresight of the morrow, a life whose arrow, once pointed forward, is bent into a timeless, directionless circle?

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